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PRINCE'S BRIDGE.

THE design for the new Prince's bridge, Melbourne, Victoria, which is here illustrated, in general appearance somewhat resembles the Blackfriars bridge, London, and in a less degree the Victoria bridge at Pimlico. It consists of three spans of 100 feet each, and one dry span—on the south bank—of 27 feet. It is the full width of Swanston Street, 390 feet. The arches consist each of 10 wrought iron ribs, the outer ribs covered with ornamental castings. In all there will be about 1,100 tons of wrought iron and 200 tons of cast iron in the structure. The piers and abutments will consist of bluestone from Saltwater or Newport quarries up to the springing line of the arches, above that of Malmsbury, in which there will be some very fine and bold carving. The largest stones in the cutwaters will weigh upward of 12 tons, and the granite columns on the piers 20 tons each.

Aside from any question of good taste in the immense amount of ornamental cast iron, the bridge will have a very bold and striking appearance. The contract has been let to Messrs. David Munro & Co., of this city, for the sum of £141,690 7s., who have now successfully carried out many large engineering works, notably the Swan Street crossing, and have now in hand the new Cremorne bridge.

The method of carrying out the work will probably be of more interest to our readers than a detailed description of the structure itself, with which they are now tolerably familiar, and which our illustration presents in an intelligible and interesting form. Work has been commenced, and a gang of men are now putting in a gullet in the south bank opposite the Flinders Street station, the material of which will be used for the construction of the south approach, together with material from a similar excavation near the Pontoon shed. Rails will be laid down from these excavations, and locomotives and trucks will be employed to convey the material to its destination, and if the material is suitable, a steam navvy will be employed in the excavation. This bank will be the largest in the colony, containing 140,000 cubic yards of material; the next largest is on the Coburg railway, and contains 120,000 cubic yards. For the construction of the piers and the widening of the river, large coffer dams will be needed, which will probably be constructed of the German patent material—traegerwellbech—or corrugated iron, stiffened with T irons or rails. For the erection of the piers and abutments, three steam cranes of 50 feet span each, running side by side, the whole length of the bridge, about 500 feet, will be provided, and another steam crane for the manipulation of the stone in the stoneyard will be employed. A siding from the Prince's bridge station will be laid in, and carried across the river on a temporary bridge for the delivery of stone, but it is probable that most of the stone will be delivered by water carriage direct from the quarries. All the wrought iron will be rolled specially for the job, but it is probable that the girders will be made in the colony, as Messrs. Munro have a large plant for such work, consisting of hydraulic riveters, multiple drills, and other special tools. The time for completing the contract is limited, two years being the time allowed, as against three years when tenders were originally called for, when the design was first accepted. A large body of men and a quantity of plant will be necessary to complete it in the time. The whole work will be under the direction of engineers trained in the Melbourne University, Mr. Geo. Higgins, the recipient of *The Argus* scholarship in 1879, being in full charge, Messrs. C. Stewart and J. B. Lewis being associated with him in his work.—*Australian Sketcher, Melbourne.*

PRINCE'S BRIDGE, MELBOURNE, VICTORIA, AUSTRALIA.

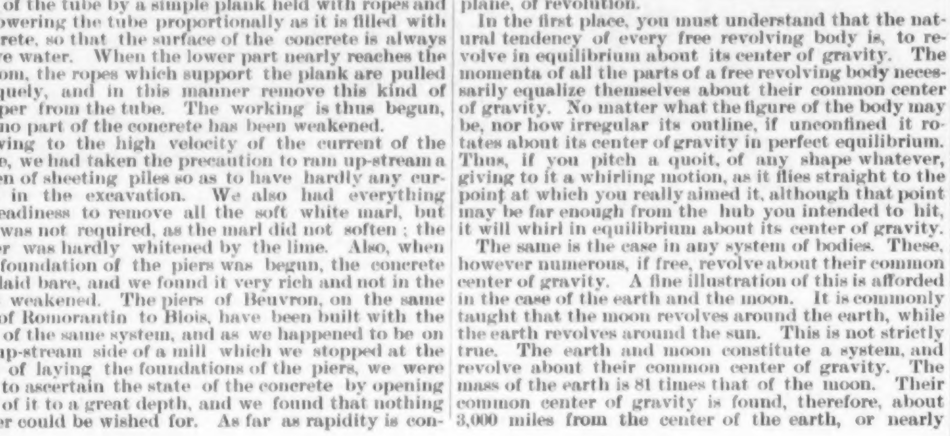
A SIMPLE PROCESS OF LOWERING CONCRETE UNDER WATER.

THE following, by Mr. H. Hende, Ingénieur des Ponts et Chaussées, is translated from the *Annales des Ponts et Chaussées* by Sergt. G. Lafosse, Assistant Master, Thomason College, Roorkee:

The piers of the large bridge built over the Loire for the passage of the railway from Blois to Romorantin have been built upon blocks of concrete lowered under the water, 1881. As we were not sure of the strength of the white marl upon which the concrete was to rest, we thought it safer to sink a great number of piles inside the area to be covered, and to drown them entirely under the concrete, as shown in Figs. 1 and 2. A difficulty then presented itself; as the distance between the piles was only to be 4 ft. from center to center, which distance often became less through the irregularity of the ramming, the use of the ordinary boxes would have been very difficult, if not impossible. We then employed the following arrangement, which is only an improvement on the old mill hopper: A square tube—16 in. side—made of ordinary planks, is lowered vertically to the bottom of the excavation, so that its upper extremity is 4½ ft. above the level of the water. This tube can be raised by means of a crab-winch; this crab-winch travels sideways over the width of the excavation upon two beams, rigidly connected together, which can themselves travel lengthways over the excavation from one extremity to the other. The whole is supported by a scaffold erected round the area of the excavation. A rope or chain is fastened to the lower end of the tube, to allow a workman to change its position by pulling in an oblique direction. Everything being thus prepared, the tube is filled with concrete up to the top, the lower end resting on the ground. By means of the crab-winch, it is slightly raised, and then part of the concrete spreads itself on the surface of the ground; the tube is then pulled into another place by means of the chain, and is allowed to rest again on the ground by unwinding the crab-winch; the upper part of the tube is then refilled with concrete. The tube is relifted, put in a new position, and so on. In this manner, the concrete arrives at the bottom of the excavation without having been in contact with the water. One precaution only is necessary, but is of the utmost importance—that is, that when the tube is lifted, the level of the concrete in the tube must not be allowed to fall below the level of the surrounding water. When the position of the lower end of the tube has been changed by means of the oblique chain, the tube retakes a vertical position, and the crab-winch places itself above it. The working is therefore very simple and very rapid; it is possible to turn at will all round a pile and to come very near it; it is also possible to make layers from 12 in. to 16 in. thick without the least trouble. Workmen learn very rapidly how to lift the tube with the crab-winch just enough to allow the necessary quantity of concrete to escape, and also how to release at once the crab-winch so that the tube rests on the ground before the upper surface of the concrete falls below the level of the water. This objection might be made—that at the beginning of the working the concrete has to be thrown into the tube while full of water, so that this first quantity of concrete is weakened. True; but this quantity would be very small.

Besides, this can be avoided by closing the lower aperture of the tube by a simple plank held with ropes and by lowering the tube proportionally as it is filled with concrete, so that the surface of the concrete is always above water. When the lower part nearly reaches the bottom, the ropes which support the plank are pulled obliquely, and in this manner remove this kind of stopper from the tube. The working is thus begun, and no part of the concrete has been weakened.

Owing to the high velocity of the current of the Loire, we had taken the precaution to ram up-stream a screen of sheeting piles so as to have hardly any current in the excavation. We also had everything in readiness to remove all the soft white marl, but this was not required, as the marl did not soften; the water was hardly whitened by the lime. Also, when the foundation of the piers was begun, the concrete was laid bare, and we found it very rich and not in the least weakened. The piers of Beuvron, on the same line of Romorantin to Blois, have been built with the help of the same system, and as we happened to be on the up-stream side of a mill which we stopped at the time of laying the foundations of the piers, we were able to ascertain the state of the concrete by opening part of it to a great depth, and we found that nothing better could be wished for. As far as rapidity is concerned, we were able to lower as much as 75 cubic yards per day and per machine. As regards costs, we paid the price estimated for the lowering by means of boxes, and our contractor, who at first showed some hesitation to adopt this system, declared afterward that it had left him a good margin. As it was believed until now that the use of the hopper only gave bad results, we have thought useful to make known this improvement on the old system. We think that this process, which might be called "the continuous hopper," can be used under certain circumstances even for very great depths.



LOWERING CONCRETE UNDER WATER.

[Continued from SUPPLEMENT, No. 531, page 8475.]

SIBLEY COLLEGE LECTURES.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

PRINCIPLES AND METHODS OF BALANCING FORCES DEVELOPED IN MOVING BODIES.

By CHAS. T. PORTER.

LET us return now from these excursions, and attend to phenomena of a more practical character.

You are to observe that, in a revolving body, each unit of matter exerts its centrifugal resistance separately, independent of every other unit. In any plane lying at right angles with the axis, those units of matter which revolve at different distances from the center have different rates of deflection, and those units of matter which follow one another in the same circle are moving in different radial directions. We may consider all the units of matter in a revolving body under these two phases separately.

First. All concentric circles of revolution may be regarded as gathered into one circle, which is called the circle of gyration. In a circular disk, the circle of gyration is found at 0·7071 of the distance from the center to the circumference. I shall have nothing to say respecting the circle of gyration, in which the entire centrifugal force of a revolving body is properly conceived to be gathered, except to point out a coincidence which we shall find to be of great practical value. This is, that the momentum of all the parts of a revolving body is also properly conceived to be gathered in the same circle. These two forces, the momentum and the centrifugal force in a revolving body, both developed by its motion, are as different from each other in their nature as it is possible to imagine. They always act also at right angles to each other. Nevertheless, these forces are properly considered to be gathered in the same circle of gyration, and they both vary directly as the distance of this circle from the center. Respecting the centrifugal force, we have seen (Fig. 2) that, at a given angular velocity, or given number of revolutions per minute, the deflection of a revolving body varies directly as the distance from the center. This is the third law of centrifugal force. The momentum of a revolving body must also vary in the same manner, because at a given angular velocity the actual velocity varies as the distance from the center, and so the momentum, M v, must vary in the same way. As already remarked, the coincidence in this respect between centrifugal force and momentum is one of much practical value. This we shall soon have occasion to observe.

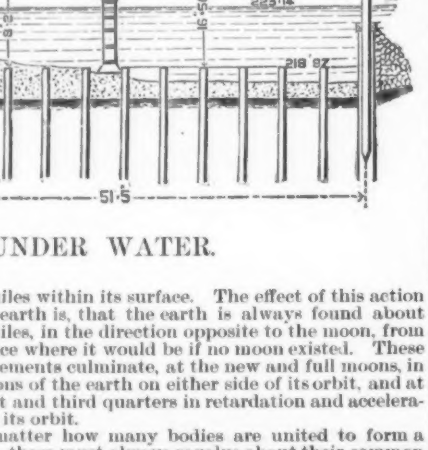
Second. We come now to what most nearly concerns us in the present discussion, namely, the centrifugal stresses which are exerted by the various units of matter in a revolving body in different radial directions, at right angles with the tangential directions in which each unit is moving. In machinery, especially in machinery which is to be run at rapid speed, it is necessary that these centrifugal stresses shall be balanced. There is only one way in which this can be done. That way is, by providing equal and opposite centrifugal forces, in the same plane, or approximately in the same plane, of revolution.

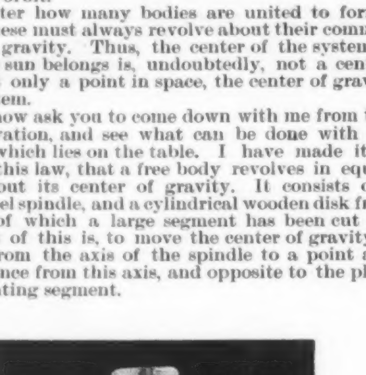
In the first place, you must understand that the natural tendency of every free revolving body is, to revolve in equilibrium about its center of gravity. The momenta of all the parts of a free revolving body necessarily equalize themselves about their common center of gravity. No matter what the figure of the body may be, nor how irregular its outline, if unconfined it rotates about its center of gravity in perfect equilibrium. Thus, if you pitch a quoit, of any shape whatever, giving to it a whirling motion, as it flies straight to the point at which you really aimed it, although that point may be far enough from the hub you intended to hit, it will whirl in equilibrium about its center of gravity.

The same is the case in any system of bodies. These, however numerous, if free, revolve about their common center of gravity. A fine illustration of this is afforded in the case of the earth and the moon. It is commonly taught that the moon revolves around the earth, while the earth revolves around the sun. This is not strictly true. The earth and moon constitute a system, and revolve about their common center of gravity. The mass of the earth is 81 times that of the moon. Their common center of gravity is found, therefore, about 3,000 miles from the center of the earth, or nearly 1,000 miles within its surface. The effect of this action on the earth is, that the earth is always found about 3,000 miles, in the direction opposite to the moon, from the place where it would be if no moon existed. These displacements culminate, at the new and full moons, in librations of the earth on either side of its orbit, and at the first and third quarters in retardation and acceleration in its orbit.

No matter how many bodies are united to form a system, these must always revolve about their common center of gravity. Thus, the center of the system to which our sun belongs is, undoubtedly, not a central body, but only a point in space, the center of gravity of the system.

I must now ask you to come down with me from this starry elevation, and see what can be done with the little top which lies on the table. I have made it to illustrate this law, that a free body revolves in equilibrium about its center of gravity. It consists of a slender steel spindle, and a cylindrical wooden disk from one side of which a large segment has been cut off. The effect of this is, to move the center of gravity of the top from the axis of the spindle to a point at a little distance from this axis, and opposite to the place of the wanting segment.





Unfortunately, this top is not altogether a free body. It has a point of support, to which it is confined. Standing on this point, it presents an illustration of the equilibrium of instability. It must be rotated swiftly enough to cause the influence of gravity to disappear, as an element disturbing its position. It will then present an interesting appearance. The line connecting the point of support and the center of gravity will become vertical, and form the axis of revolution. The spindle will be inclined from this axis, and in revolving around it, will describe a hollow cone, open at the top, while the disk will present the appearance represented. In preparing this toy, I removed the segment gradually, spinning the top after taking off each slice, and was much interested in observing the enlargement of this cone on each successive spinning. The cuts show a plan view of the top and the appearance of the top when spinning, which exhibits very beautifully the tendency of a free body to revolve about its center of gravity. While spinning, I mark the spindle near the top with paint. When we examine it afterward, we find this paint on the side of the spindle in line with the place of the missing segment. It could not be anywhere else. That line described the exterior of the cone.

The discussion we had a few minutes ago enables us to understand, also, the phenomenon which is presented in the spinning of this or any other top. Instantaneous motion from a state of rest is impossible. Gravity requires time in which to act. By revolving a top with sufficient velocity, any excess of weight appears on opposite sides of the fulcrum, or point of support, at so nearly the same instant as to beat gravity.

I shall have occasion presently to return to this subject of the disposition of a free body to revolve about its center of gravity, and to call your attention to some practical applications of this principle, which the experiment with the top will have placed us in a good position to understand. First, however, we will consider the case of bodies which are compelled to revolve about a fixed axis. This is generally the case in machinery, where the journals of revolving bodies are confined in stationary bearings.

Here any excess of matter on one side of the revolving body, by its resistance to deflection, produces a stress on the bearing or journal box, during each revolution, successively in all directions, precisely like the stress that is felt when one revolves a sling. In order to get a proper idea of this stress, we must dismiss from our thought all the balanced portion of the body, and consider the unbalanced portion as if it were revolving alone, precisely like a sling.*

There is always one plane, passing through the axis of a journal, in which the resistance to motion of the machine with which the revolving body is connected is less than it is in any other plane. This is known as the plane of least resistance. It is generally the horizontal plane. In this plane, a vibratory motion is imparted to the whole machine, and thence is communicated to the building in which the machinery is contained. This vibration is always unpleasant, and sometimes it becomes productive of serious consequences.

Let us consider how serious this want of equilibrium is, and in what a rapid ratio it increases with increase of speed. We have seen that the centrifugal force of 1 lb., making 1 revolution per minute, in a circle of 1 foot radius, is 0·000341 of a pound. But suppose the speed to be a thousand revolutions per minute. Then the centrifugal force of 1 lb., in this circle, is a million times this, or 341 lb. At five thousand revolutions per minute, it is twenty-five million times this, or 8,500 lb. This force increases also as the circle of revolution is enlarged. Instead of revolving at one foot from the center, let our one pound revolve at this speed at a distance of only two feet from the center. The stress exerted by it is now 17,000 lb. This would at once shake down any work of human hands (unless the pyramids be excepted), the natural rate of vibration of which synchronized with that of the revolving body. You see what a fine point it must be to attain complete equilibrium in machinery which is to be run very swiftly.

I had once to balance dynamos which were causing vibration in a great building. The maker declared the revolving armatures to be already perfectly balanced; that they had been made in such a manner that they were necessarily balanced, and therefore did not need any balancing. He resisted their being balanced for a long time, and to the serious prejudice of his employers. On trial, one of them turned out to be 14 oz. out of balance, on a radius of 7 inches. The speed was 930 revolutions per minute. A computation, which any one of you can now make, showed the disturbing stress to be 151 lb.

We next pass to the consideration of the practical method of balancing these centrifugal stresses in machinery. For our ability to balance all those centrifugal forces or stresses which are developed approximately in one plane of revolution, we are indebted to the fact, already mentioned, that, at different distances from the center, centrifugal force and momentum vary in the same ratio, namely, directly as the distance. Thus at 10 feet from the center 1 lb. balances 10 lb. opposite to it at 1 foot from the center. The weight multiplied into the distance through which it moves, on a given angular change of position, is the same in each case. The centrifugal force varies in the same ratio, although for a totally different reason. In moving through a given angle, 1 lb. at 10 feet from the center exerts the same centrifugal force that is exerted by 10 lb. at 1 foot from the center, because its rate of deflection is ten times greater. Thus it is that, although momentum and centrifugal force are so entirely different in character, and are exerted in directions at right angles with each other, still both vary in the same ratio. On this principle, that bodies whose momenta are in equilibrium with each other exert the same centrifugal force, we are readily able to obtain what is known as the static balance, which answers perfectly well where all parts of the body revolve approximately in the same plane, as is the case with flywheels and ordinary pulleys.

In the case of a rod or bar, the mode of finding out if and how much the body is out of balance would be by trying it on a knife edge. But in the case of the bodies with which we have to deal, we do not know the direction in which the excess of weight lies. These bodies are therefore tried by securing them on an arbor, and rolling this arbor on plane surfaces. The practical requirements for this trial are as follows:

* There are some persons by whom all this is denied. I content myself here with the statement. On subsequent pages I will give the demonstration.

First, with respect to the arbor. This should be as small as is consistent with rigidity, each end should be of the same diameter and perfectly cylindrical, and its axis should be made to coincide exactly with the axis of the bore in which it is inserted.

Second, with respect to the planes. These should be perfectly true, flat surfaces, and should lie in the same horizontal plane, and should be broad enough for the arbor to roll on them without the perfection of surface of either arbor or planes being impaired thereby in the least degree. Both planes and arbor should be as clean and dry as possible. The least particle of either dust or oil ruins the action. If these conditions are carefully complied with, almost absolute accuracy is attainable by this method.

The first object must be to find the precise direction in which the excess of weight lies, or if, as is often the case, there are numerous inequalities, then the one direction in which their disturbing effects are all gathered. This point or radial line will fall to the bottom. It is not easy to hang a plumb line from the axis, but it is easy to hang two plumb lines over the arbor, and the point midway between those is directly under the axis. We find here a slight error produced by the rolling friction of the arbor on the planes. The heavy point will not fall quite to the bottom. This error must be eliminated. This is readily done, by letting the body revolve through equal small arcs in opposite directions. The amount of the error from this friction thus appears, and the precise direction wanted is found. This is then carefully marked in a permanent manner. The planes must be perfectly level, or the true direction will not be shown.

The next thing is, to find the amount of weight that must be applied opposite to this point, on the same diametral line, in order to balance the wheel. For this trial, the marked point is brought up to the horizontal plane passing through the axis, which must be carefully found, and weight is added opposite to it sufficient to keep it there.

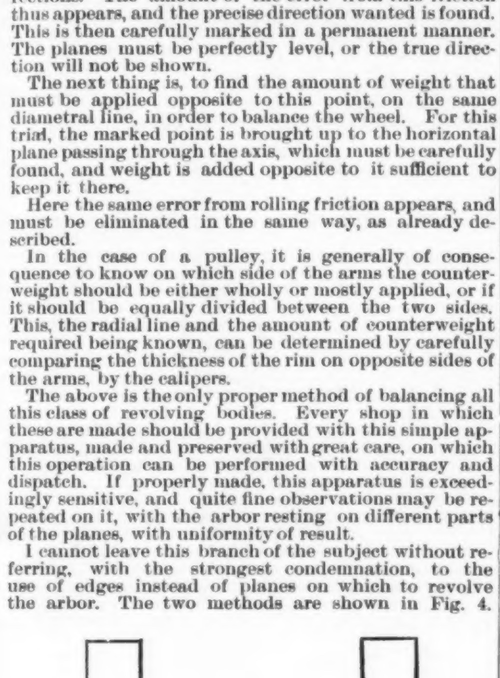
Here the same error from rolling friction appears, and must be eliminated in the same way, as already described.

In the case of a pulley, it is generally of consequence to know on which side of the arms the counterweight should be either wholly or mostly applied, or if it should be equally divided between the two sides. This, the radial line and the amount of counterweight required being known, can be determined by carefully comparing the thickness of the rim on opposite sides of the arms, by the calipers.

The above is the only proper method of balancing all this class of revolving bodies. Every shop in which these are made should be provided with this simple apparatus, made and preserved with great care, on which this operation can be performed with accuracy and dispatch. If properly made, this apparatus is exceedingly sensitive, and quite fine observations may be repeated on it, with the arbor resting on different parts of the planes, with uniformity of result.

I cannot leave this branch of the subject without referring, with the strongest condemnation, to the use of edges instead of planes on which to revolve the arbor. The two methods are shown in Fig. 4.

Fig. 4



The wonder is how any one, having used the edges once, can ever do so again. The weight rests on two *points*, where the cylindrical surface of the arbor bears on the edges. As the arbor revolves slowly, the edges plow a groove around it, varying in depth according to the weight of the pulley and sharpness of the edges, but always sufficient to ruin the arbor, and raise also a corresponding burr on each side of the groove. The balancing action is, moreover, effectually deadened. And still, the absurd idea seems at some time to have been almost universally ground into the mechanical mind, that the balancing arbor must be rolled on the narrowest possible surfaces. So these edges are shown in all illustrations of this operation that I have ever seen, and they are found very commonly in shops where balancing is attempted. The fact is, that a cylinder resting on a plane bears only on a line, and the longer this line is, the more sensitive the apparatus will be, and the less liability there will be to injury of the surfaces, under a considerable weight resting upon them. True parallel cylinders, bearing fairly on true planes, are of course assumed.

But many bodies, after having been balanced in this way, are found to be out of balance when they come to be run. Here appears the well known distinction between a static and a running balance, a distinction which is a constant puzzle to those who are ignorant of the very simple principle on which this distinction is found. This principle is, that all revolving bodies, or parts of bodies, must be balanced in their own separate planes of revolution. It is idle to attempt to balance an excess of weight revolving in one plane, by a corresponding excess opposite to it but revolving in a different plane, perhaps at a considerable distance. The only effect of this is, that we get two disturbing forces in the place of one. When tried at rest, these balance each other well enough, but when their centrifugal stresses come to be developed by revolution, those are not opposite to each other, but each one produces its disturbing effect in its own plane of revolution.

Another meaningless expression, that is often heard in common speech, ought to be noticed here. This is, that every revolving body should be balanced for its own speed. If a revolving body is balanced, it is balanced for all speeds. If it is only partially balanced, then it may be that the unbalanced portion will not produce a noticeable disturbing effect at a moderate speed, but will do so at a greater speed. So when one says that such a body is balanced for such a speed, he really means, though perhaps he does not know it, that it is balanced sufficiently to answer at that speed. Now all revolving bodies ought to be balanced accurately. Then they are balanced for any speed. This is by the way.

Fig. 5

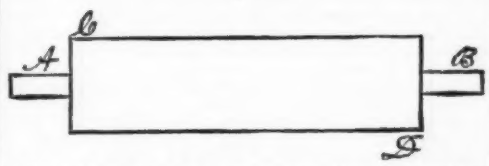


Fig. 5 shows a drum of small diameter and considerable length, revolving about an axis, A B, and supposed to be supported in bearings at the ends. If this drum were tested in the manner already described by rolling its journals on planes, an excess of weight at C would obviously balance an equal excess of weight at D. But when revolving, each of these excesses would exert its centrifugal stress in its own plane of revolution, just as if the other did not exist. These necessarily produce their disturbing effects through the two bearings. That at C produces its disturbing effect mostly, but not wholly, through the bearing at A, and that at D produces its disturbing effect mostly, but not wholly, through the bearing at B. The proportions are divided between the two bearings, according to their distances from the point at which each excess of stress is exerted.

In this illustration the positions of the disturbing weights are supposed to be known. In practice, however, the case is very different. Neither the number nor the positions, nor the amounts of the various inequalities are ever known or can be known in practice. The case is one full of difficulties. These difficulties may be greatly lessened by care in a place where care is not very generally taken, that is in the foundry. By taking great pains, especially in the making, setting, and securing of the cores of such castings, and pouring these in a vertical position, a close approximation may be made to truth of the interior surfaces. Sometimes a world of trouble and expense may be saved by such a system. Then, by setting the drum for turning accurately by the interior surface, the work of balancing is reduced to a minimum.

But, after all, such a drum must be balanced, and how is this to be done? Suppose that one of you were shown a drum, say one foot or less in diameter, and five feet long, nicely turned and polished outside, but the interior surface of which was inaccessible for turning, and you were asked to balance that drum, what would you do?

If you remember what I am now going to tell you, this is what you will do, if ever you have such a case. You can approximate pretty closely to a balance by the method of gauging the thickness of the rim, and also of the hub and arms with double-ended calipers. This should be done systematically, the surface being divided into squares for the purpose, and the result plotted. The two ends should be treated separately. A second sheet should be plotted from the first one, showing only the excesses of thickness above the minimum. By careful study of these you can determine pretty nearly the amount and location of the counterweight required at each end, and thus make the subsequent operation more expeditious and accurate. It is obvious that rolling on planes will not help you in such a case as this. If the care which I have described above in moulding and setting in the lathe has been observed, this preliminary operation will be unnecessary, but, with the irregular interior surfaces usually to be found in such castings, it is important.

The final operation is as follows: You will stand your drum on end and spin it, as I spun the top. In doing this much care is to be taken. First, we need to be sure that the drum is revolving about its axis, and not about any other point of support. The best way to insure this is to make the centers in the ends of the spindle large, and rest the lower one on a stud having a spherical end which enters the center a short distance. The spherical end enables the top of the drum to move freely from side to side. This center must be well lubricated. Complete lubrication is best secured by drilling a small hole down the axis of the stud, which is fixed securely in its position. This hole connects with a horizontal hole or tube. This leads to a convenient place at any distance away, where it turns upward to a level higher than that of the stud. This passage being filled with oil to the level of the top of the stud, on oil being added at the farther end, a corresponding quantity flows out to lubricate the center.

Another thing remains here to be provided against. Sufficient centrifugal force may be developed by the revolution, at the lower end of the drum, to lift the drum on the stud and make it fly out. The possibility of this must be prevented by having the lower end of the spindle surrounded by a permanent casting, fitting it very loosely, but presenting a parallel bearing, rising at least an inch above the top of the stud. All this provision should be made in a substantial casting, well bedded in masonry in the earth at the level of the shop floor.

The upper end of the drum is the end which you are first to balance. The journal at this end should be allowed to run in a hole about half an inch larger than itself, in a timber framing strong enough to resist any strains that can come upon it. The best and simplest way of driving the drum is by a belt which is held to its surface, or to the surface of the lower journal, by a tightener. When the speed of the drum has been got up to the point required, the tightener is loosed, and the belt drops away, leaving the drum to revolve freely. If it is moving fast enough, it will stand; if not quite fast enough for this, the upper journal will beat in the wooden hole. In either case it will describe a cone similar to the one described by the spindle of the top. Now touch the journal with marking paint, and then bring the drum to rest. The mark will be found on the light side of the drum, just as on the spindle of the top, for this also has been revolving as a free body about its center of gravity. You have now determined the location of the counterweight—in line with the paint mark on the spindle, and *on the same side*. The amount of the counterweight must be ascertained by repeated trial, until the spindle at this end runs dead true. You will then repeat the same operation for the other end. Now, perhaps, you think you will be done, but you will find you are not. On trying the first end again, it will not run perfectly true. This is perhaps partly because the drum at first may not have revolved about its axis. If the centrifugal force then lifted it on the stud, as far as the bearing would permit, then there was an error in its point of support, but this error cannot exist on subsequent trials, because then the lower end of the drum will be balanced.

The counterweight added to the end last balanced, however, affected the other end in some degree. You may, on this account, have to reverse the drum several times before you get each journal to run *perfectly* true, and your job is not finished until this is done. I think by this time you must begin to realize the importance of the most extreme care, in the foundry, and in turning the drum, so as to shorten the labor of balancing as much as possible. If not, you will realize this when you have balanced a few of these drums.

A very important practical application of the principle that a free body will revolve in equilibrium about its center of gravity, is made in the centrifugal machines, which are now in general use for separating fluids from solids, in sugar refineries, in laundries and bleacheries, in the manufacture of chemicals, and more recently in creameries. These machines have been designed in several different forms, adapted to these different uses, and their details require considerable study in order to be well understood.

It will not, therefore, be desirable in this place to attempt anything more than to explain the general manner in which the application of this principle is made in their construction.

It had been found impossible to balance centrifugal machines when running in fixed bearings. These had been made in the first place for the purpose of separating the sirup from sugar, but they threatened to shake down the refineries in which they were tried. However carefully they were themselves balanced, the charge of sugar threw them out of balance at once. In this emergency, an American, David M. Weston, conceived the idea of hanging the basket, through the perforated sides of which the sirup is strained, at the lower end of a short shaft, which is suspended from the bottom of another vertical shaft by a ball and socket joint. This allows the basket to swing freely in all directions, hindered only by the friction produced by its weight, and the feather or key by means of which it is driven. The driving pulley is keyed on the upper shaft, which runs in fixed bearings and receives the strain of the belt. This was the original form of construction. The basket, with or without its charge of sugar, revolved in equilibrium about its center of gravity, and vibration disappeared. The invention soon came into use in sugar refineries everywhere, and from these its application has been extended to other industries, as already stated. The form, however, has been much changed, and subordinate devices have been added, but without affecting the general dependence on this principle. For example, large baskets, in which three barrels of sugar are drained of their sirup at each charge, are now, for purposes of convenience, driven from beneath, instead of from above. Here the ball and socket joint is at the lower end of the vertical shaft, and the basket at the upper end. This presents essentially the construction above described in an inverted position. This construction involves the equilibrium of instability. To meet this, a bearing is provided at the upper end of the shaft, near to the basket, and this bearing is allowed only a limited amount of play. This play is restrained within the desired limits by a number of India rubber springs, placed around it radially at equal distances apart, and confined within the framing of the machine. The successful working of these machines, in this respect of freedom from vibration, depends on having these springs rightly proportioned in strength, so as to resist the eccentric tendency of the basket sufficiently, but not too strongly. The proper degree of resistance has been found by experiment. A number of other modifications of the original design have been made for the purpose of adapting the machine to other uses. Those I will not further refer to, having said enough to answer my purpose, which, as already stated, is only to call attention in a general way to these important and varied applications of this principle.

We now come to consider a remarkable distinction, in this respect of equilibrum, presented between free bodies and bodies which revolve about axes held in fixed bearings. This distinction is one by which many minds are sorely puzzled, and which occasions very absurd views to be held by some persons on the general subject of equilibrium in revolving bodies.

We have seen that when a free body revolves, its heavy side approaches the axis or center of revolution, so that the lightest side describes the largest circle. This it must do, in order that the center of revolution shall coincide with the center of gravity of the body. We observed this action in the experiment with the top. In that case the center of gravity was removed only a short distance from the axis of the spindle. We may,

however, imagine cases in which a great weight is on one side of the center of gravity, and a small weight is in equilibrium with it, at a proportionately greater distance on the other side. When such a body revolves freely about its center of gravity, the greater circle that is described by the lighter side is exhibited in a degree far more marked than we saw it in that experiment. But when a body revolves about a fixed axis, the opposite effect is produced. Now the heavy side of the body tends *from* the center or axis of revolution. The freedom of motion, or the elasticity of the body, one or both of which always exist in some degree, allows the body to yield more or less under this stress, so that the heavy side describes the larger circle. This is always found to be the case with bodies revolving on journals held in fixed bearings, and we find the heavy side by marking it as the high or prominent side, when revolving. We balance such a body by removing a portion from the side so marked, or else by adding something opposite to that side. This is true of all bodies which revolve about fixed axes, whatever their speed. The best illustration and practical demonstration of the fact that in these cases the stress is always from the center, in the direction of the greatest weight, is afforded by the crank disks of horizontal high speed engines. In these we place a counterweight to neutralize the disturbing effect exerted by the reciprocating parts of the engine. This counterweight is placed opposite to the crank, and it performs its office by exerting a radial stress in the line of the greatest weight. The speed makes no difference in the nature of this action. I have run an engine, 6 in. bore of cylinder by 12 in. stroke, in which the reciprocating parts weighed only 40 lb., and were exactly balanced by the counterweight, at speeds which were estimated to exceed 2,000 revolutions per minute, the engine not showing the least tendency to vibration.

Now, why should the heavy side of a revolving body tend *toward* the center of revolution when the body is free, and *from* the center when it is confined? Why, in the former case, should the light side, and in the latter case the heavy side, describe the larger circle? There can be no question about the fact of this contrary action. What is the explanation of it? The answer to this question you will find, when you understand it, to be an extremely simple one. Like all other puzzles, this, when explained, will cease to be a puzzle.

The fact is that, in these two cases, the action of a revolving body in this respect is controlled by entirely different forces. When we reflect upon the opposite nature of these tendencies, it seems evident, even before we have learned anything about their causes, that these causes must be wholly different. We are quite prepared to receive the evidence, which shows that different forces produce these opposite tendencies. Nothing short of this could account for them.

In considering this action in a free revolving body, or system of bodies, we have nothing to do with centrifugal force. Centrifugal force does not appear as an element or factor in the problem. The force which determines the disposition of a free body to revolve about its center of gravity is the momentum of the several units of matter of which the body is composed. It is to be remembered that momentum acts tangentially, while centrifugal force acts radially. The two are thus always exerted in directions at right angles with each other, and, as will be explained presently, neither one has any power or can produce any effect at all in the direction in which the other is exerted. Another fact respecting momentum is important also to be borne in mind. The momenta of opposite portions of a revolving body, being exerted on tangential lines, can never be opposite to each other in the same line, as opposite centrifugal forces are, but must act on lines parallel with each other, on opposite sides of the center, as on the lines, A D and F H, Fig. 1.

Now, in the revolution of a free body, as already stated, centrifugal force does not appear, but the momenta of opposite portions of the body, acting in the manner above shown, at once equalize themselves about the center of gravity, as obviously they must do, unless their free action is hindered in some way. It is true that, when the momenta of a revolving body are in equilibrium, the centrifugal stresses are in equilibrium also. Then why may not the latter affect this action, in a free body, as much as the former? I answer, because under these conditions momentum is the controlling force.

It will be interesting, first, to compare the motion of a revolving body in its arc of revolution, in which direction its momentum is exerted, with its corresponding motion toward the center, under the action of centripetal force. In Fig. 2, A O C represents the angle of 24° and A O B the angle of 12°. The arc of 24° is 4·845 times its versed sine. The arc of 12° is 9·6 times its versed sine. Here we have indicated the law, which in the smaller angles is followed exactly, that the versed sine diminishes as the square of the arc diminishes. Let us follow this comparison down to 1″ of arc. The length of 1″ of arc, in terms of the radius, is 0·000 004,848.13. The length of the versed sine of 1″ is 0·000,000,000,011,752. The motion of the mass in its arc, while traversing 1″ of arc, is thus seen to be 412,550 times the motion which it has toward the center in the same time.

It is true that, in the former case, we have velocity, which is the effect of a previous application of force, and in the latter case we have only a force, for the distance through which this force acts is inappreciable, and it may be claimed that the two are not comparable. The force which produced the velocity may have been a great force acting through a short distance, or a small force acting through a great distance; while the deflecting force may be great or small; having acted only through an insensible distance, it has imparted no appreciable velocity. And it may properly be claimed that force and velocity cannot be compared in this way.

There is, however, a method of making this comparison which shows clearly enough that the relative motions of the body in the two directions do substantially represent the real controlling nature of momentum in this case. We have seen that in a circle of one foot radius, at a speed of 54·166 revolutions per minute, the deflecting force exerted on a revolving body is equal to the weight of the body. At this rate of revolution, the body is moving in its arc with a velocity of 5·7 feet per second. Through what distance must a force equal to its weight be exerted in order to impart to the body this velocity? The law of uniform acceleration is, that the velocity acquired varies as the square root of the distance through which the accelerating force has acted. $v \propto \sqrt{d}$.

Making our computation from the data furnished by falling bodies, we find $32{,}166 : 5{\cdot}7 :: \sqrt{16{\cdot}083} : \sqrt{0{\cdot}5}$. Therefore a body must fall through 0·5 foot in order to acquire a velocity of 5·7 feet per second; or a force equal to its weight must be exerted on the body through 0·5 of a foot, in order to impart to it this velocity.

Here, then, we have the energy which is the effect of a certain force having been exerted through 0·5 of a foot of distance. In centripetal force we have the same force, but which, at the point of deflection, the only point to be considered, has not acted through an appreciable distance. In the tangential direction the body is in motion with this velocity. In the radial direction it is not in motion. The objection that force cannot be compared with velocity is well taken, but it admits the case in favor of momentum. Energy and force without motion, or actual and potential energy, are not commensurable. Force, as compared with even the least degree of energy, is powerless, the element of distance being wanting.

In a free revolving body, then, momentum is the controlling force. The momenta of the opposite parts of the body equalize themselves, unhindered, about the center of gravity of the body, as the axis of revolution. This they do, acting on tangential lines, just as water, when opposing currents meet, forms a whirlpool.

It is, however, necessary, in order for this action to take place, that the body shall be absolutely free. The least force, applied to fix the center of revolution of a body at any point other than its center of gravity is sufficient for this purpose, because momentum cannot oppose any resistance to the action of such a force. This is by reason of the law that a force or energy, is powerless in the directions at right angles with that in which it is exerted. By resolving a force into its rectangular components, we ascertain the degree in which it can produce motion in directions which form various angles with its own direction. We observe this power to diminish as we approach the rectangular direction, and to disappear entirely when we reach it. No matter how great the force or energy may be, it is entirely powerless in the rectangular direction. This is illustrated in the familiar statement, that infinite force could not overcome the effect of gravity, and straighten a horizontal thread. This law inspired Dr. Lardner, in one of the lectures of the scientific course delivered by him in New York many years ago, to perhaps the most remarkable example ever given of unconscious versification. His statement, expressed with mathematical precision, when divided into verse, reads as follows:

> "There is no force, however great,
> Can stretch a horizontal line,
> Though this be infinitely fine,
> That it shall be exactly straight."

By reason of this powerlessness of any force in directions at right angles with that in which it is exerted, it results that when a body, instead of being free, is made to revolve about a fixed axis, the case, in the respect we are now considering, becomes completely changed. The momentum is exerted on tangential lines. The line connecting each unit of matter with the axis of revolution is a radial line, at right angles with the direction of its energy. The latter, therefore, however great it may be, has no effect on the axis of revolution.

This is true even in the extreme case of the whole weight being on one side of this axis. Indeed, this is always the proper way of regarding any such action. Those portions of the body which are in equilibrium are properly disregarded as canceling each other, and the unbalanced portion only is considered, since this only can produce a disturbing effect. Thus in Fig. 1, disregarding F, let us suppose the weight to be gathered at A, and to be revolving about the center, O. The energy of this weight is exerted in the tangential direction, A D. It cannot, therefore, be felt at all at O, because it is exerted at the point, A, and the line, A O, is at right angles with the line, A D. If the body, A, could advance along the straight line, A D, even the least distance, so that the line, A O, would form with A D an angle larger than a right angle, even in the least degree, then the energy of the body, A, would begin, though in an infinitely small degree, to be felt at the center, O. This, however, is impossible. The rectangular direction is unalterable, and so the momentum of a body revolving about a fixed axis has not the least power to oppose any force by which this axis has been determined.

In the case of a free body, we saw why it was that centrifugal force disappeared as an element or factor in determining the center of revolution. Now we have seen why it is that in the case of a body revolving about a fixed axis momentum disappears in the same determination. It is obvious that a body revolving about a fixed center has not the least disposition or tendency to revolve about its center of gravity or any axis other than that which has been determined for it. We see why it is that no such tendency exists or can exist in even the least degree. No force can be felt at the center, except a force exerted in a radial direction.

It is under these conditions of revolution about a fixed axis that centrifugal force, when not exerted in degree sufficient to overcome the cohesion of the body, first makes itself manifest. This it does when an excess of matter exists on one side of the axis. As was just now observed for momentum, and as has been observed for centrifugal force itself, it is only this excess of matter which is to be considered. The resistances to deflection of the balanced portions of the body are to be disregarded. It is this resistance of the unbalanced portion only, which tends to disturb the stability of the body.

If not perfectly controlled by the inertia of the latter, then, at some point in its revolution, this unbalanced portion moves a greater or lesser distance along the tangential line, taking the whole body with it, when not elastic, before its deflection is accomplished. Vibrations of machinery are, therefore, occasioned by the incomplete deflection, at some point in their revolution, of the unbalanced portions of the revolving parts. This is the cause of all vibrations, except those produced by the unbalanced action of the reciprocating parts, of which I have still to speak.

It has now, I think, been made clear, why a free revolving body and a body revolving about a fixed axis present so complete a contrast with each other; in the tendency in the former of the lightest side, and in the latter of the heaviest side, to describe the largest circle.

This concludes what I have to say on the subject of balancing centrifugal force, which is the only force, developed in revolving bodies, that we are in practice called upon to balance. Indeed, as we have seen, if the centrifugal stresses are in equilibrium, the momenta are in equilibrium also. Want of time will make it necessary to postpone to another occasion the consideration of the remaining division of my subject, which I will then present in its most important practical connection.

In bringing the present lecture to a close, I would express the earnest hope, that the advantages afforded by this institution may be so improved by you all, that, at the end of your course of study, you will leave it with well balanced minds; and that, however important may be the movements, whether mechanical, or social, or political, or religious, and I think these will be important, in which, in after life, you may become engaged, you will never lose your equilibrium.

THE USE OF IRON IN FORTIFICATION.*

BEFORE describing the cupolas proposed for coast defense, we shall say a few words about the means used for protecting rifled mortars and mitrailleuses.

Cupola for Mitrailleuses.—A design for a cupola for a five-barreled 1½ in. Hotchkiss mitrailleuse has been proposed by Major Schumann, and is shown in Fig. 1. This cannon, which is capable of firing thirty shots per minute, with an effective range of 2,000 yards, would be especially useful, says Gen. Brialmont, for repulsing a violent assault. It is cheap ($3,000), and can be protected against artillery, up to the moment that it is to

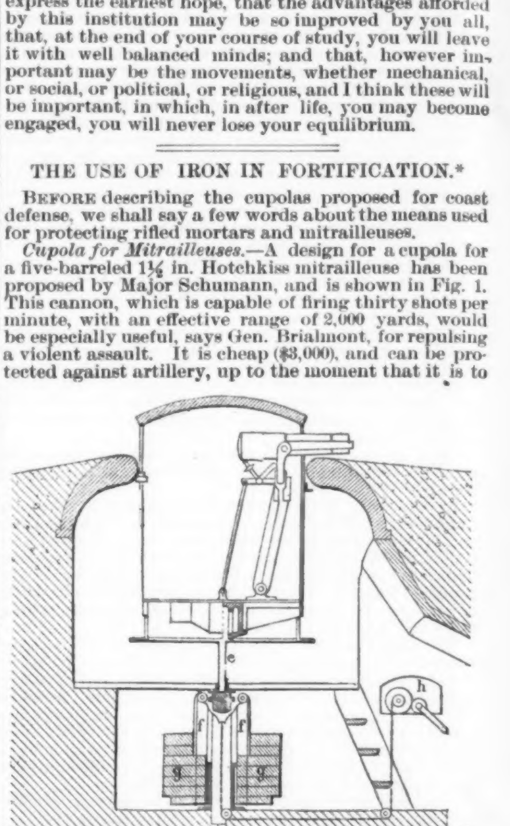


FIG. 1.—SCHUMANN CUPOLA FOR HOTCHKISS GUN.

enter into action, by a vertical motion. As its role is to fire at assaulting columns, the enemy cannot use its artillery against it without running the risk of firing upon its own troops. It will suffice, then, that the vertical wall, which appears only at the moment of firing, be of strong iron plate, proof against rifle balls. As for the spherical top that comes flush with the hard-iron ring of the *avant-cuirasse* as the gun disappears, this is constructed of rolled iron of proper thickness. Owing to the small diameter and the hidden position of this disk, the thickness given it is but 4 or 4½ inches.

The cylindrical, iron-plate part is 5½ feet in diameter. In order to obtain a vertical motion of from 12 to 15 inches, the iron-plate frame rests, through a metallic pivot, *e*, upon a step-bearing that moves in a slide, *f*, whose external surface serves as a guide to annular counterpoises, *g*, that balance the entire system, to which motion is given by the winch, *h*, through the intermedium of a chain.

It will be seen that in order to put the cupola in the position in which it conceals the gun, it is necessary to pull the latter back. This is a very simple operation, since the carriage consists of a jointed parallelogram. In placing it in battery, the top of the carriage is seized by a very strong click fixed to the side of the cupola, and this holds it in an absolutely stable position.

The Schumann Cupola for an 8-inch rifled Mortar.—As rifled mortars fire curved shots, it is impossible to completely conceal the protecting cupola from the enemy's sight. The mortar is set into a cast iron sphere 3¾ ft. in diameter (Fig. 2), which exactly closes the

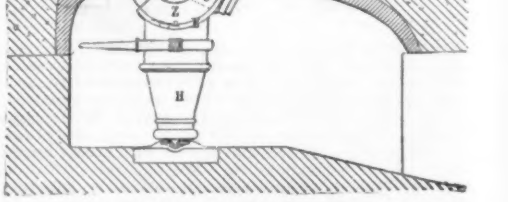


FIG. 2.—SCHUMANN CUPOLA FOR A 9 INCH MORTAR.

aperture of the same size at the apex of the cupola, which is itself protected by a mass of concrete. This latter forms a conical funnel whose apex is occupied by the sphere, and the angle of whose opening is limited by the extreme positions of firing. In a normal position, the sphere, through vertical sectors, C, that serve as trunnions, rests upon the circular cheeks of a metal frame that surmounts a wooden shaft terminating be-

* Continued from page 8472.

neath in a movable pivot, H. A rotary motion is effected through a capstan and levers.

The friction of the sphere upon the cheeks is such that the stability is perfect (when aim has once been taken) and cannot be disturbed, even by the shock of a projectile against the sphere. We should, then, have to overcome a very strong resistance in revolving the sphere to aim high, were not the sectors disengaged in the first place by lifting the whole thing by means of eccentric rollers moved by a weighted lever. Then the sphere is made to revolve by the action of an endless screw until the index, *z*, is upon the proper division of a graduated limb affixed to the cheeks. The eccentrics thus deposit the sphere upon the cheeks without disturbing the aim.

Saint Chamond Cupola for Coast Defense.—It is impossible to roll a plate of iron more than 20 or 24 inches thick. We obtain, it is true, much heavier hammered steel plates; but we have already remarked that although the breakage of a steel plate of a ship's armor would be attended with comparatively little inconvenience, it would put a cupola out of service. It became necessary to find some sort of wall arrangement that should be proof against breakage, and the following is what the Saint Chamond works propose: A plate of hard metal (steel, casehardened iron, or compound iron), from 24 to 28 inches thick, is placed between two pieces of teak-wood (Fig. 3). Externally, this armor is

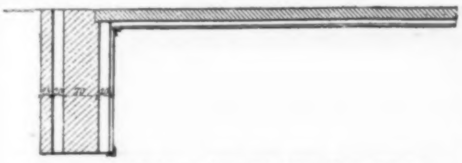


FIG. 3.—CUPOLA FOR COAST DEFENSE.

protected by a jacket of rolled iron from 8 to ten inches thick. In the absence of conclusive experiments, it is hoped that such a wall will behave as follows: Upon striking it, any projectile of large caliber will make a clean perforation in the rolled iron plate, but will not reach the hard plate until it has lost a great part of its live force. Admitting, however, that the shock be sufficient to fissure, and even break, the hard plate, the fragments of the latter will remain united and held between the two wooden coverings, so that the cupola will remain standing, and be able to continue its service.

It is of considerable importance not to have the external rolled iron plate too thick; and the number of segments may be reduced without exceeding for each of them the maximum weight recognized as manageable, while at the same time a reduction may be made in the number of the vertical joints and large bolts that always constitute the weak part of such structures.

The roofing plates likewise are of rolled iron 9 inches thick, and rest, through the intermedium of teak-wood, upon a double plate of steel and a metal frame. This roof would certainly resist the 396 lb. projectile of a 10-inch rifled mortar from which it was shot nearly vertically with a remanent velocity of 980 feet. The internal diameter of the cupola is 39 feet; it is mounted on a hydraulic pivot, thus reducing the work of passive resistances by four-fifths. The recoil is limited to 4¾ feet by a hydraulic brake.

For high aiming, the movable part of the carriage revolves around a pin situated in front, and rests behind upon a telescopic hydraulic press, whose piston and cylinder are respectively jointed with the carriage and the lower frame of the turret. The hydraulic maneuvering is effected by a 150 horse power steam engine that actuates a system of pumps capable of furnishing 3¼ gallons of water per second, which they compress in an accumulator. This latter has to be always under pressure in order to allow salutes to be fired. These apparatus are situated in a casemate under the turret. The compressed water is led to the various parts by piping.

The two guns are placed once for all so that their planes of firing shall intersect at a distance of about five thousand yards.

The gunner stands upon the steps between the pieces and looks through a telescope which is placed in the bisecting plane and slides with slight friction through the breech.

The distance of the object to be fired at is measured from an external station and telephoned to the chief of the turret. The gunner, with his eye to the telescope, holds the distributing lever. His business is to follow every movement of the ship that is to be fired at. When the guns are loaded and ready to be fired, the officers inform the gunners, who have only to press an electric contact in order to set the piece off.

It requires 18 men to maneuver this cupola, and its cost is $600,000.—*Le Genie Civil.*

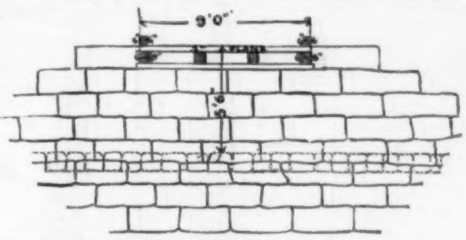
A DESCRIPTION OF THE CHARLOTTESVILLE WATER WORKS, ALBEMARLE CO., VA.*

By EDWARD D. BOLTON.

CHARLOTTESVILLE is the shire town of Albemarle County, Virginia. It has within the corporation limits a population of about 3,500. The University of Virginia is located just outside the corporation, and this, with the students and persons connected therewith, together with the people living in the immediate vicinity, comprises about 2,000 more. The town and University having united in the introduction of water, provision is made for supplying a population of 5,500 and a future growth.

The plan adopted is that generally known as the "gravity system." A dam has been built across a deep and narrow valley in the Ragged Mountains, about 5½ miles beyond the town, through which a stream, fed by springs, flows, and a pipe-line has been laid, passing through University grounds, to the town. The sides of the valley are very steep and underlaid with ledges, and are covered for the most part with grass and timber, a small area of cultivated land lying farther up the valley and above high-water level. The stream flowing through the valley will furnish, in ordinary seasons, a supply far beyond the present demand, but provision has been made to store the surplus rain-fall as well, and the reservoir has such storage capacity that it will carry the town through any possible drought. The dam is 45 ft. high above the level of the meadow, and 530 ft. long, and the reservoir has a water area of 32 acres at high-water level, and a capacity of 189,000,000 gallons. It is built of earth, with a core of rubble masonry through the center, well laid in cement, and pointed on the inner or water side with Portland cement. The core is 8 ft. wide at the base at the lowest point, the width at the base varying with the height, and 4 ft. wide on top. The foundation in the center is about 15 ft. below the general surface of the meadow, and 10 ft. wide. The materials at the bottom of the foundation are solid rock, very compact rotten rock, and clayey gravel. Where the gravel and the softer portions of the rotten rock were found, a bed of concrete, 30 inches deep and 12 ft. wide, was put in, and the masonry started from this. The concrete was also brought up on the inner side of the wall to the original surface of the ground in places, according to the character of the soil. The stone used was a granite quarried near the site of the dam, and was very hard and compact, the finer-grained stone being reserved for the gate-house. The cement used was the "James River" brand, manufactured by H. O. Locher & Co. at Balcony Falls, Va., and gave very good results. The earthwork is 12 ft. wide on top and about 190 ft. at the bottom, the slopes being 1½ to 1 on the outside, and 2 to 1 on the inside, the inner slope being broken by a berme 7 ft. wide about midway from top to bottom, and the upper slope being paved.

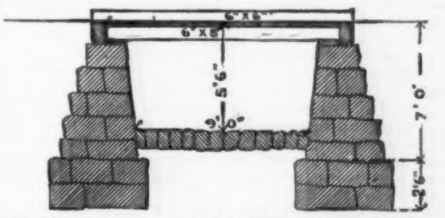
As the masonry was carried up, the earth was put in place in layers and thoroughly rolled with a grooved roller, being wet when necessary, to make it compact. All the teaming was done over the embankment, and



WASTE WEIR.—LONGITUDINAL SECTION.

made to cover as much ground as possible, to avoid rutting. After the earthwork was brought up to its full height, the outer slope was dressed down, the top of the dam leveled, and top soil was put on, nine inches in depth, and the whole outer slope and top seeded.

The gate-house, which is set out into the pond, is built of the finer-grained stone, with quarry faces and squared joints. It is arranged with two chambers, either of which can be used independently to supply water through the pipe-line to the town. It is 14 ft. by 27 ft. on the top, the chambers being 8 ft. by 10 ft. and 8 ft. by 8 ft., divided by a partition wall 3 ft. thick, and



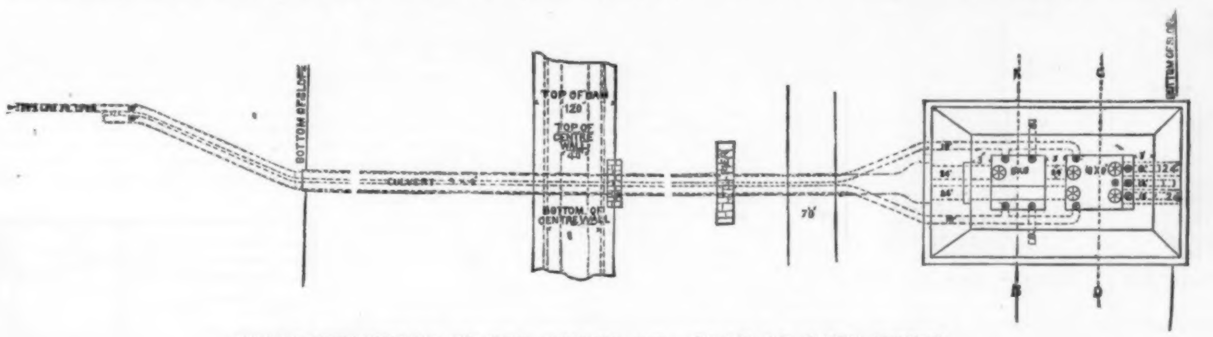
WASTE WEIR.—TRANSVERSE SECTION.

all the walls are 3 ft. wide at the top. The dimensions at the bottom are 22 ft. by 37 ft., and the foundation, 24 ft. by 38 ft., rests upon a bed of very compact rotten rock, $7\frac{5}{10}$ ft. below the floor of the chambers.

To admit water to the chambers, six 12 inch cast-iron flanged pipes are built into the masonry at different heights, each provided with a gate bolted to it to control the flow of water through them, so that the water may be taken from near the surface, where the water is clearer and freer from sediment.

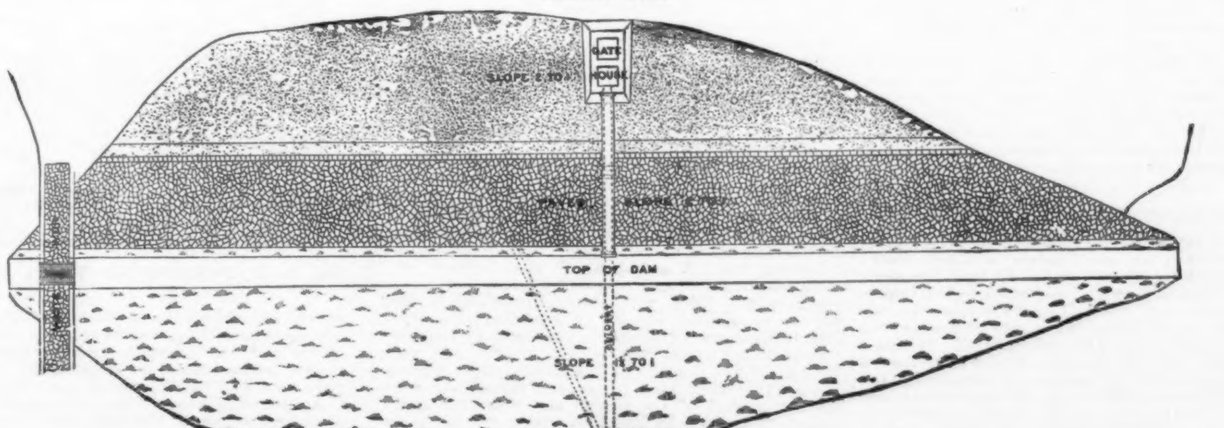
In this section of the country, after heavy rains, all the streams and ponds are very much discolored by the reddish clay carried along by the water, but which gradually settles out. Therefore, the best and clearest water will always be found nearest the surface; and to supply water to the town, the inlet pipe just below the water would be opened, to allow water to enter the

* Read before the Boston Society of Civil Engineers, November 16, 1885.—From the *Journal of the Association of Engineering Societies.*



CHARLOTTESVILLE WATER WORKS, 1885.—PLAN OF GATE HOUSE.

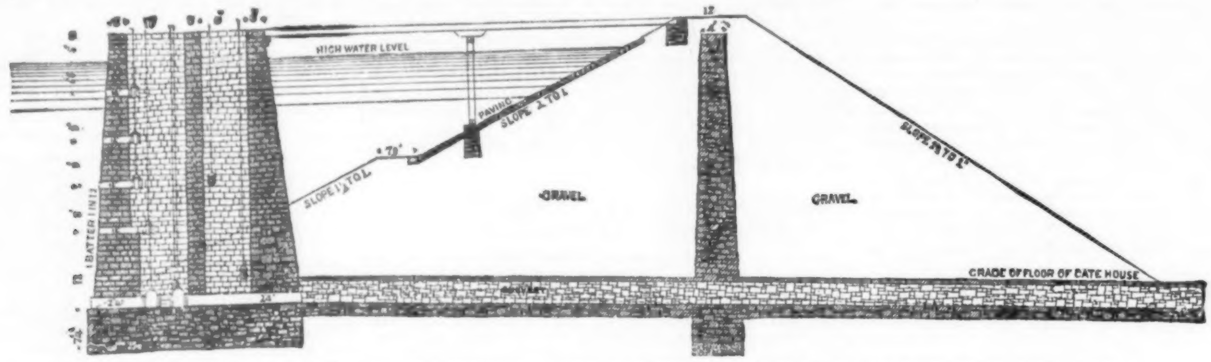
RESERVOIR.



CHARLOTTESVILLE WATER WORKS, 1885.—PLAN OF DAM

chamber. Copper wire nettings, secured to plates so arranged that they may be dropped over the inner flange of the gates, form the screens. These can be easily removed and cleaned, as they are light and convenient to handle; and as the pipe opened is always under the water, they are not liable to catch rubbish, such as leaves and sticks, or to need frequent cleaning.

The supply pipes to the town are 10 in. flanged pipe, two to each chamber, each provided with a gate. These pipes are carried through the masonry of the gate-house, under the dam through the culvert, and brought together just beyond the foot of the outer slope into one pipe leading to the town. These are so left that an additional line can be carried to the town, when it becomes necessary, without disturbing the work in the gate-house or dam.

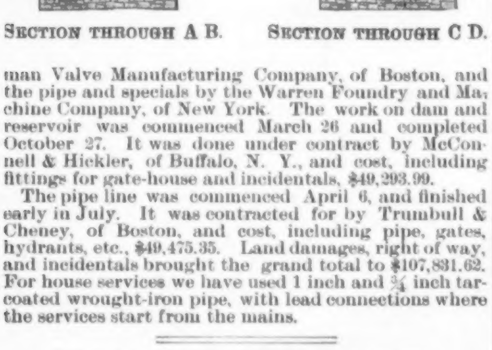


CHARLOTTESVILLE WATER WORKS, 1885.—CROSS SECTION THROUGH GATE HOUSE AND DAM.

To empty either chamber, there are two lines of 24 in. flanged pipe, fitted with gates, one line running directly from the first chamber to the waste culvert, which passes through the dam to the meadow below into the bed of the brook; and the other from the first chamber to the second, and then from the second to the waste culvert, thus connecting the two chambers, and also allowing the second chamber to be emptied independently of the first. If it is necessary to draw all the water out of the reservoir, the gates on both these lines of 24 in. pipe can be opened, and the water will be drawn completely down to the bed of the original brook. The gates used are the ordinary pattern of flanged water-gates, and were furnished by the Coffin Valve Company, of Boston.

At present, only a single line of 10 inch cast-iron pipe runs to the town, which is reduced, after taking off a 6 inch distribution, to an 8 inch along the main street to the farther end of the town. The distribution is made with 6 inch and 4 inch pipes, which are connected together, with the exception of two lines, where it was not practicable to do so, to insure complete circulation.

There were $5\frac{6}{10}$ miles of 10 inch, $\frac{1}{10}$ of a mile of 8 inch, $1\frac{3}{10}$ miles of 6 inch, and $1\frac{7}{10}$ miles of 4 inch, a total of $9\frac{6}{10}$ miles of pipe laid. There were also 139 specials, 42 stop gates, 38 double-nozzle fire hydrants and 7 single-nozzle fire hydrants set. On the main, 5 single-nozzle hydrants were used as air-cocks, and gates were put in about a mile apart, thus dividing the line into sections. The gates and hydrants were furnished by the Chapman Valve Manufacturing Company, of Boston, and the pipe and specials by the Warren Foundry and Machine Company, of New York. The work on dam and reservoir was commenced March 26 and completed October 27. It was done under contract by McConnell & Hickler, of Buffalo, N. Y., and cost, including fittings for gate-house and incidentals, $49,293.99.



SECTION THROUGH A B. SECTION THROUGH C D.

The pipe line was commenced April 6, and finished early in July. It was contracted for by Trumbull & Cheney, of Boston, and cost, including pipe, gates, hydrants, etc., $49,475.35. Land damages, right of way, and incidentals brought the grand total to $107,831.62. For house services we have used 1 inch and ¾ inch tar-coated wrought-iron pipe, with lead connections where the services start from the mains.

THE CHALAIS-MEUDON BALLOON.*

THE results obtained by means of a dirigible balloon constructed at the Chalais military works were made known by me last year. In 1885 the same balloon made three new ascensions, which I shall briefly describe in the present note. Let me remark in the first place that, before beginning a new campaign, the balloon had to be modified in certain parts. It was a question, in fact, of filling the gaps in the experiments of 1884, and especially of accurately measuring the velocity of the balloon with respect to the surrounding air. As experience had shown me that a party of two aeronauts was not sufficient to make measurements properly, it became necessary, before all things, to lighten the apparatus. I easily succeeded in doing this by modifying the mode of construction of certain parts, such as the ventilator, piles, commutator, etc.

* Note read to the Academy of Sciences by Capt. Renard, November 23, 1885.

As the motor had given rise to various accidents (especially on the 12th of September, when the movable ring was rendered unserviceable, and had to be replaced by one constructed at Mr. Gramme's works, and on the 8th of November, when the current was closed in short circuit, owing to a fall of portions of the brush wires), I resolved to substitute a new one therefor, having but two brushes, that could be more easily inspected and replaced. The construction of this was confided to Mr. Gramme. Our eminent electrical engineer delivered an excellent motor, which was admirably balanced, and of a weight about equal to that of the first.

The transmission of motion likewise had to be modified. Since, by reason of the inevitable distortions of the car, the pinion keyed to the motor and the wheel fixed to the screw shaft were exposed to variations in their relative positions that last year had produced partial dislocations and breakages of the teeth, I suspended the entire train of gearings from the screw shaft itself. Moreover, the pinion shaft was connected with that of the motor through an elastically keyed coupling-box that allowed the train to shift itself considerably without interfering with the transmission, and that formed a sort of double joint.

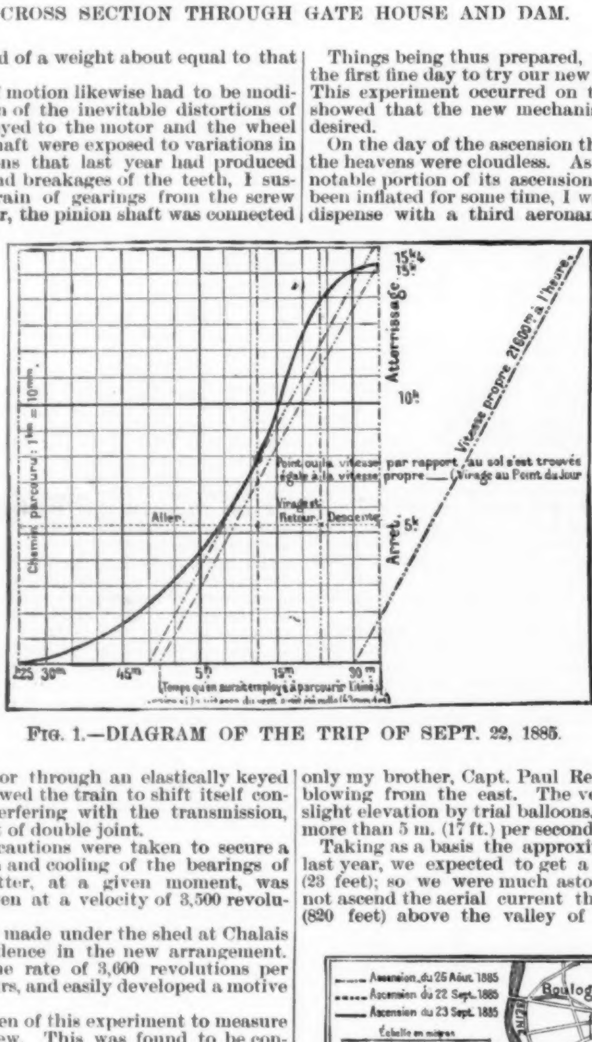


FIG. 1.—DIAGRAM OF THE TRIP OF SEPT. 22, 1885.

Finally, minute precautions were taken to secure a continuous lubrication and cooling of the bearings of the pinion, which latter, at a given moment, was capable of being driven at a velocity of 3,500 revolutions per minute.

A preliminary trial made under the shed at Chalais gave me entire confidence in the new arrangement. The motor ran at the rate of 3,600 revolutions per minute for several hours, and easily developed a motive power of 9 horses.

Advantage was taken of this experiment to measure the thrust of the screw. This was found to be connected with the intensity of the current by the formula $H = 0.753$, $C = 17.3$, where H represents the thrust of the screw in kilogrammes, and C the current in amperes.

This formula is very exactly verified for values of C that vary from 0 to 108 amperes. It may be admitted without serious error that it is applicable to cases in which the balloon is freely yielding to the stress of the screw.

Finally, I applied myself to improving the pile, so that the duration of its action might be prolonged without an increase in its weight; and I was fortunate enough to succeed in this by slightly modifying the composition of the exciting liquid.

I now reach the very simple but very accurate process for measuring the speed proper. As the screw is in front of the balloon, I could not think of employing an anemometer, since the indications thereof would be too high; but, on the contrary, there was nothing to prevent the use of an aerial log. This I got up in the following way: A gold-beater's skin balloon of 120 liters (about four and a quarter cubic feet) capacity was partially filled with illuminating gas in such a way as to remain exactly in equilibrium in the air. This balloon was attached to the central extremity of a bobbin on which was wound exactly 100 meters (328 feet) of silk thread. The slightest stress sufficed to unwind this spool when the central thread was pulled. The other end of the thread was wound around the operator's finger. In order to make a measurement, the operator freed the balloon, which, moving rapidly to the rear, and reaching the end of its travel, produced a perceptible shock upon the finger holding the thread. The moment of starting and that of the final shock were shown upon a chronometer that gave the tenth of a second. Although the stress transmitted to the little balloon during the unwinding of the silk was very feeble, it was necessary to take it into account. Repeated trials in a closed room showed that the little balloon moved 7 m. (23 ft.) per minute, or 0·117 m. (4½ in.) per second, under the influence of this slight stress. If, then, we call t the duration of the unwinding in seconds, the space got over by the dirigible balloon during the operation will be $100 + 0{\cdot}117t$, and the velocity will be given by the formula:

$$v = \frac{100}{t} + 0{\cdot}117t.$$

Things being thus prepared, we took advantage of the first fine day to try our new mechanism in the air. This experiment occurred on the 25th of August, and showed that the new mechanism left nothing to be desired.

On the day of the ascension the weather was dry and the heavens were cloudless. As the balloon had lost a notable portion of its ascensional power from having been inflated for some time, I was obliged this time to dispense with a third aeronaut, and so started with only my brother, Capt. Paul Renard. The wind was blowing from the east. The velocity, measured at a slight elevation by trial balloons, did not appear to be more than 5 m. (17 ft.) per second.

Taking as a basis the approximate estimates made last year, we expected to get a velocity of about 7 m. (23 feet); so we were much astonished that we could not ascend the aerial current that prevailed at 250 m. (820 feet) above the valley of Chalais. The screw,

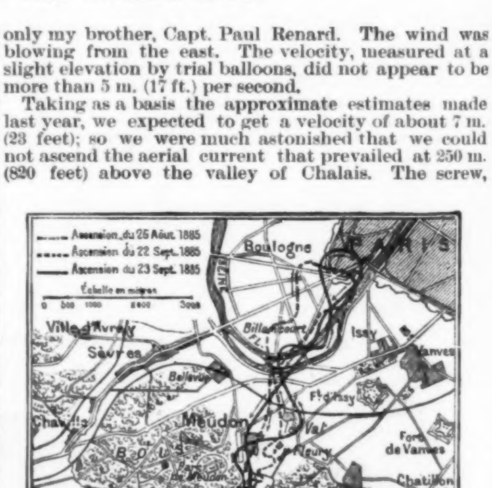


FIG. 2.—MAP SHOWING TRIPS MADE IN 1885.

which was driven at a velocity of 55 revolutions per minute, ran with perfect regularity; and yet we were slowly but continuously drifting backward. Nevertheless, as we desired to prolong the experiment, and were afraid of being carried over the woods toward Chaville, we headed a little to the right, and, under the combined action of the wind and of the velocity proper, the balloon soon took a southerly direction and hovered over the bare plains of Villacoublay, a very favorable spot for landing. The backward motion continued to occur, and, after a trip of 50 minutes, the balloon descended near the farm of Villacoublay,

whither I had steered, and where a force of army laborers from Chalais was awaiting us. This first experiment, although it gave us full confidence in our motive mechanism, nevertheless deceived us in one respect. We had relied too much upon our forces; the velocity of the balloon, which had last year been estimated without direct measurement, was less than we had supposed, and, on another hand, the wind that prevailed at an elevation of 250 m. (820 feet) was evidently stronger than that near the surface. We at length felt the necessity of making accurate measurements of the velocity, and patiently awaited moderate weather. By reason of bad weather, a conclusive experiment could not be made until during the course of the following month.

On the 22d of September the wind was blowing from N.N.E., that is to say, from the direction of Paris, and its velocity in low regions varied between 3 and 3·5 m. (10 and 11½ feet) per second. We decided to start. This time the balloon was manned by three aeronauts: Capt. Paul Renard, in charge of measurements and various observations; Mr. Duté Poitevin, an aeronaut employed at the Chalais establishment; and myself. I did the maneuvering of the rudder and motor.

The start occurred at a quarter past four, the weather being damp and misty. The screw was set in motion, and the balloon was headed toward Paris. At first there were a few lurches, but these I soon succeeded in overcoming, and, from this time on, despite robbed the balloon of a portion of its ascensional force. The experiments just described have allowed me to establish upon important bases some fundamental formulas that may serve for estimating the resistance of balloons like La France, inclusive of netting and car. I think it well to give these here, since they differ greatly from those that it was possible to deduce from the previous, very incomplete trials, and with which I had to content myself in establishing my project.

The resistances measured are much greater than I had believed them, and as every one else before me had.

If we designate by R the resistance in kilogrammes of La France moving pointwise; by v its velocity in meters per second; by θ the work of direct traction (motive work in kilogrammeters); by T the work of the screw shaft in kilogrammeters; and by T^1 the work at the terminals of the motor in kilogrammeters, we deduce from our experiments the following formulas:

$$(1)\quad \begin{cases} R = 1{,}189\ v^2 \\ \theta = 1{,}189\ v^2 \\ T = 2{,}300\ v^3 \\ T^1 = 2{,}800\ v^3 \end{cases}$$

At the rate of 10 meters per second we shall have:

$R = 118·9$ kgm.
$\theta = 1{,}189$ kilogrammeters.
$T = 2{,}300$ " (31 h. p.)
$T^1 = 2{,}800$ "

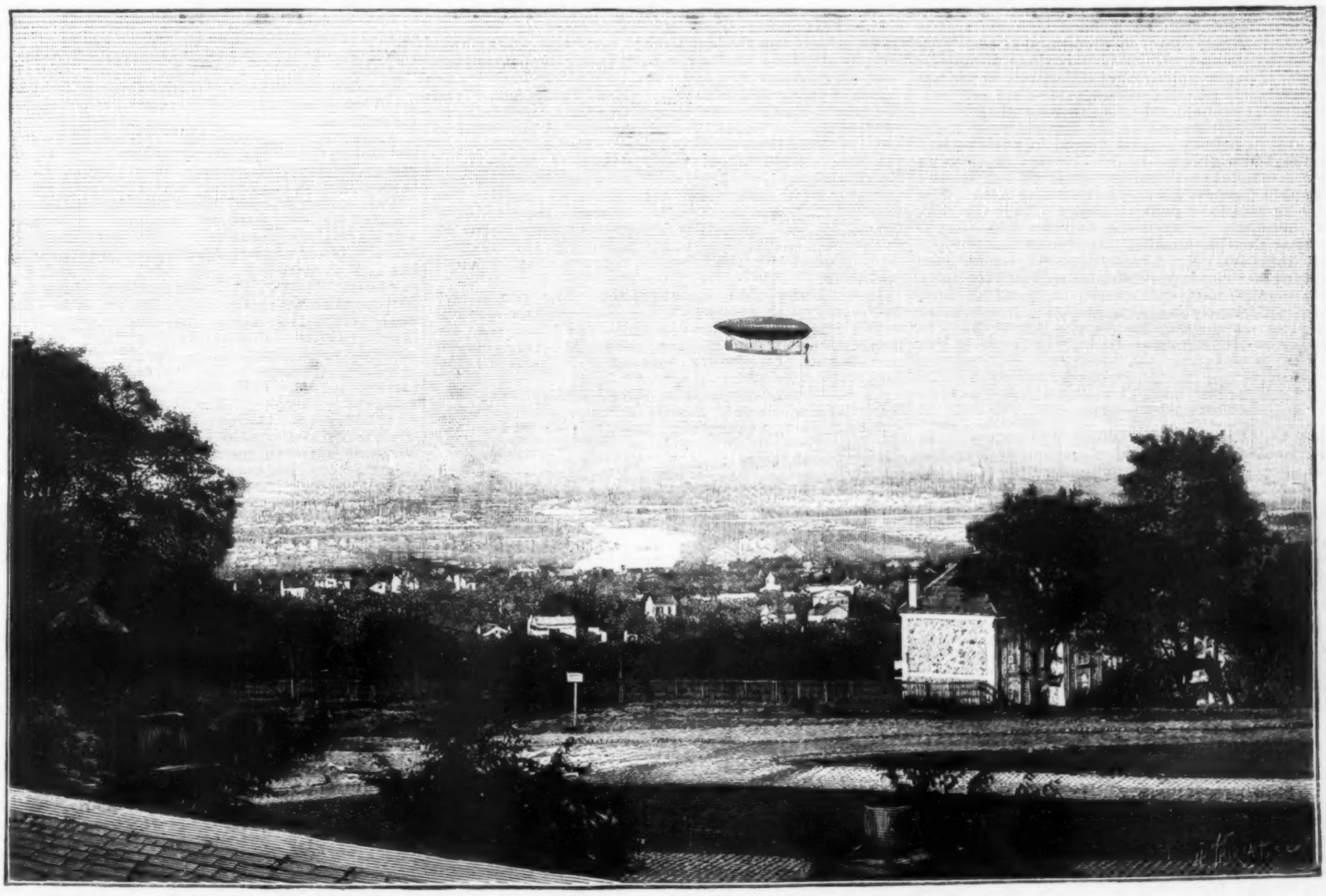


FIG. 3.—THE BALLOON LA FRANCE OVER POINT-DU-JOUR, AT PARIS.

the wind, the balloon, passing over the village of Meudon, crossed the railroad over the station at 4 h. 55 m., and reached the Seine at 5 o'clock, toward the western extremity of Billancourt Island. At this moment we measured the velocity, and found it to be exactly 6 m. (19·68 feet) per second. Meanwhile, the balloon continued its course against the wind, and approached the fortifications of Paris. At 5 h. 12 m., after a trip of 47 minutes, it entered the inclosure over bastion 65.

The weather was becoming more and more misty, and the moist fog weighted us down and forced us to sacrifice very large quantities of ballast. Under such circumstances, it was imprudent for us to proceed farther, and so we decided to return.

The putting about was easily effected, and, favored this time by the aerial current, the balloon approached its starting point with surprising speed. We could no longer distinguish Chalais, as it was completely hidden by the fog, and we had to steer by taking the Billancourt bridge and Meudon station in succession as direction points.

Eleven minutes sufficed to bring us over the landing plain, and to allow us, on our return, to pass over a space that cost us 47 minutes in going. The balloon was put about in order to keep it close to the wind, and ten minutes later the car touched the lawn from whence it had started. During this trip the balloon reached an altitude of but 400 m. (1,312 ft.).

The following day, in the presence of General Campenon, Minister of War, and General Bressonnet, president of the Committee on Fortifications, the balloon La France made another ascension, and one that succeeded as well as that of the preceding day. The measurements of velocity were renewed, and the results of the two days found to agree. The route was just about the same as that of September 22. The wind was lighter, and carried us toward Paris. It took 17 minutes to make the trip forward, and 20 for the return. Landing was easily effected, and the balloon returned exactly to its starting point.

For want of ballast, the trip could not be further prolonged, the ascension of the preceding day having

In a general way, we shall have for a balloon of diameter D (in meters):

$$(2)\quad \begin{cases} R = 0·01685\ D^2\ V^2 \\ \theta = 0·01685\ D^2\ V^2 \\ T = 0·0326\ D^2\ v^3 \\ T^1 = 0·0397\ D^2\ v^3 \end{cases}$$

—*La Nature.*

LIQUID FUEL.

MANY attempts have been made during the last twenty years to use mineral oils as fuel, but none of them have resulted in commercial success. Mr. Aydon was the first engineer who succeeded in this country in burning liquid fuel in a steam boiler. He effected his object by injecting the fuel in the form of spray by the aid of a jet of steam; and nothing to rival this system has ever been discovered. In South Russia and on the Caspian liquid fuel is used to a considerable extent to generate steam, but even there what we must term the Aydon system has been adopted. Petroleum in all its varied forms is too well known to render it necessary that we should say much about it here. An average sample contains—carbon, 85 per cent.; hydrogen, 13 per cent.; and oxygen, 2 per cent. Its calorific value is very high because of the large quantity of hydrogen. Petroleum oils are of almost endless composition, and are obtained by distillation from petroleum or crude rock oil, as it is sometimes called. Petroleum will evaporate theoretically about 18 lb. of water per pound of oil. Petroleum oil is of higher value, as it will evaporate as much as 25 lb. of water per pound. Its calorific value may be taken as two and a half times that of coal, while the value of the crude oil is a little less than twice that of coal. In practice, however, no such results have ever been obtained; and because attention is being once more directed to the subject, and hopes may be formed which cannot be realized, it is well that we should say something of the practical difficulties which stand in the way.

In order to give liquid fuel every advantage, we shall take the value of coal in the following comparison at 9s. 4d. a ton, that is 0·05d. per pound. The lowest price at which "dead oil," creosote, or any other form of liquid fuel can be had is 1d. a gallon, and at this the supply is very limited. The specific gravity may be taken at not far from 0·9, so that a gallon of it would weigh about 9 lb.; but with coal at 0·05d. per pound, we get 20 lb. for 1d., so that, again giving petroleum all the advantage of even numbers in lieu of fractions, it is just twice as dear as coal. To be burned, therefore, with equal economy, it must be twice as efficient; but a practical evaporation of 20 lb. of water per pound of petroleum has never been got. Indeed, this ratio is beyond the theoretical powers of the crude oil. It may, therefore, be taken as granted that liquid fuel has no claim to be a cheap fuel. At the price of even 3d. a gallon it could not be used at all for making steam, provided coal was accessible. Before proceeding to consider any other aspect of the matter, it is well to finish with the question of relative economy. Petroleum is a very difficult thing to burn to advantage, because of the enormous quantity of smoke which it produces. The smoke itself does not necessarily represent much loss of fuel, but the deposited soot does, because it coats the heating surfaces with an admirable nonconductor; and there is a strong tendency to the production of what is known as greasy soot, which clings and sticks, and can only be got rid of with much trouble. To prevent smoke, the oil must be burned with a large supply of air in a brick-lined chamber, which will prevent the rapid cooling of the gas and partial extinction of the flame. This entails a very important modification in the structure of a boiler, for reasons which will be apparent hereafter. The only possible place where liquid fuel may be used with advantage by English engineers is at sea; but any attempt to use it in the existing boilers practically deprives them of the heating surface of the furnaces, because these must be lined with firebrick if combustion is to be complete. The bulk of the work will be transferred to the combustion chamber and tubes, and this would entail a high chimney temperature, and consequent waste, if the combustion chamber temperature was raised above what it now is when coal is burned. It appears certain that the total efficiency of a marine boiler burning liquid fuel instead of coal must be lowered. This is a simple deduction from theoretical considerations, but it has hitherto been borne out in practice, for the Himalaya, the steamer which recently made a run to Leith with liquid fuel, could not keep steam to anything near the proper pressure, and the experiments made at Portsmouth have so far ended in the same way. We do not say that a special boiler may not be devised to get over the difficulty, but in any case it must be, we believe, much larger than the existing type.

A serious objection to the use of liquid fuel is that a very considerable quantity of steam is required to blow the fuel into the furnace. This steam acts on the fuel precisely as it would on water in an injector. It is condensed, and enters the furnace as so much water, which has to be all re-evaporated. It is true that it gives up its heat in the first instance to the fuel, but it makes no return whatever for the second evaporation, which is dead loss. If the steam were not made the second time, its use for blowing in the fuel might in one sense be neglected, but with re-evaporation it stands for so much waste of heat. The quantity used has never been ascertained with any precision, but it is of importance. It renders the use of the supplementary feed necessary to keep up the level of the water in the boilers, and this entails constant risk of incrustation. Indeed,

when the voyages are long and the pressures high, it would be impossible to work at all in this way, and steam would have to be furnished by a supplementary boiler working with salt water at a low pressure; or else special distilling apparatus must be provided to furnish fresh water to the main boilers. We have here a second and very serious obstacle to the use of liquid fuel at sea.

The great merit which is claimed for liquid fuel is that, owing to its superior efficiency, either a much smaller quantity of it than of coal may be carried, or that a given weight of it will take a ship much further than would a similar quantity of coal. It is for this reason that it is being tried in the Navy. We shall grant, for sake of argument, that liquid fuel may be carried with as much safety as coal. Bulk for bulk, however, it will occupy about as much space. If, however, it can be shown that a ton of liquid fuel will do as much as a ton and a half of coal, then space may be saved or the duration of cruises prolonged. It may also be urged, and with justice, that the number of hands required in the stokehole will be largely reduced. Such points as these are well worth consideration in the Navy, and we are glad to see that an experiment is being tried with liquid fuel. In the mercantile marine petroleum has no chance whatever; the price must always prove fatal to its success. In the Navy, price is a secondary consideration, and as fuel for war ships it may yet be adopted. But it must not be forgotten that even a small shell exploded in a mineral-oil tank would produce the most appalling results.

The principal point to be decided is, however, the possibility of burning the oil to advantage at sea. This has yet to be proved. Until this is done, it may be mere waste of paper to point out objections to the use of a comparatively volatile, inflammable fluid as a fuel. The next point to be decided is the possibility of getting it at a sufficiently low price. Experiences on the Caspian are valueless, because liquid fuel can be had there for next to nothing. In this country, Mr. Aydon was very successful in burning "dead oil" at Messrs. Field's candle factory, Lambeth, to begin with. The oil could be had for a penny a gallon. This was only because there was no known use for the refuse left in the still after the illuminating oils, such as "paraffine," had been obtained. Mr. Aydon, however, used a good deal of dead oil; the supply diminished, and the price rose. It remains to be seen whether mineral oil could be had in sufficiently large quantities in this country to render its use possible even in the British Navy in time of peace.—*The Engineer.*

MALT MAKING.*

By H. STOPES.

THE fact that the important industry of malt making has hitherto attracted so little attention, or received such scant notice from the numerous members of the Society of Arts, warrants the production of a paper concerning it at this time. Were it still continuing in the iron fetters of the law that so long held it in a state of complete bondage, any paper would be capable of effecting but little reformation. As the making of malt is now as completely free as any other useful and lawful process of manufacture, it may be decidedly beneficial to all engaged in it to have it introduced and discussed by the members of this Society.

Few industries can claim an earlier origin than malting. Probably no other in Britain has made so little progress, or been affected so slightly by the revolutions that the past and present generations have practically made in every other department of human employment. This is the more remarkable, as malting is distinctly an industry in which science can aid empirical methods of development.

The fettering influence of the Malt Tax is the alleged cause of the want of development manifested by every department of the trade, but this cause is inadequate to account for such singular lack of improvement as has been witnessed. There is but a slight difference in making malt now from the practice of a hundred or even a thousand years ago. The vast majority of maltsters for ages have gone on making malt, generation succeeding generation, apparently content to perform the whole work by manual labor, aided by two, or at the outside three, tools of the rudest and simplest character, and almost entirely oblivious of the most commonplace of the scientific considerations that should guide them in their work. The chief implement they used was probably the first that civilized man made, or, perhaps more correctly speaking, that first helped to civilize man, viz., a shovel or spade of wood. Although naturally the buildings in which malt has been made have gradually improved in construction and gained in size, some of the newest and largest malt-houses are still constructed in entire and utter ignorance of the primary requirements of the barley or other grain which is made into malt within them.

To brewers and distillers, malt is a material of fundamental importance. Several generations of farmers fancied it was also of great importance to agriculture in the dual sense of ruling considerably the production of corn, and aiding the stock-keeper in his processes of feeding. The great bulk of mankind should take an interest in the curious changes effected in many species of the *Graminaceæ* by germination, for, altogether apart from the production of alcohol, they gain properties capable of exerting material influence upon the well being and comfort of varied members of the human family.

Malt is any corn, grain, or seed which can be artificially germinated within certain limits, so that it admits particular influences affecting the constituents of such corn or seeds to be developed at the will of the maltster. Other grain than barley has for ages been made into malt, and other processes also than germination have been successfully adopted to make barley, maize, or rice, etc., into malt.

It is difficult to define the nature or limit of the influences of germination or gelatinization. In the first place, our knowledge is yet capable of much extension, and the subject itself is very intricate. This accounts for the small impress left by the few great minds that have already approached the question in detail or as a whole. Many generations of men have doubtless tried to explain why and how malt differs from the corn from which it was made, but to this moment no satisfactory or explicit solution has been offered.

Of the antiquity of malt making little need be said, for such inquiry is of little practical value. Still, numerous historic references invest the subject with a certain interest. The power of many seeds to produce malt was discovered at a very early stage of man's development. No positive evidence of the existence of malt has yet been furnished from the *debris* of the Swiss Lake dwellings, but some day it probably will be. Many classical writers of antiquity allude frequently to the preparation, use, and effects of certain fermented liquors made from barley, wheat, etc., by the ancient races of Europe, Asia, and Africa. Herodotus attributes the invention of beer to Isis, wife of Rameses II. Pliny, Aristotle, and Strabo speak of it, and Diodorus affirms that some beer was so palatable as to be scarcely inferior to wine. As Pliny speaks of liquor made from steeped corn, and Wilkinson found traces of malt at Thebes, we may fairly conclude that malt was generally used, and consequently that it has a high antiquity. All the nations of Europe in earlier ages made beer, and the consumption of malt in Europe alone has been truly immense for upward of 2,000 years. The process of manufacture described by Geopinus indicates that it was to all intents and purposes made by the ancient Britons in the same manner as in many primitive maltings in Europe and our own country, which are at work at this moment.

Malt occasioned legislation at a very early date, and appears to have confounded farmers and political economists five centuries ago as completely as it has those of the present generation. From the ninth year of Edward II. (1315) until the forty-third of Victoria (1880), which was the last time a law was passed materially affecting malting as an industry, legislation has been effected almost every year.

It is of more importance to define the nature of the changes induced in corn by malting than to find its inventor; but the origin of malt making is shrouded in less obscurity than these changes. The secret has not yet been revealed to our weak powers of observation. Many analyses have been made by numerous chemists, and of course such differences as exist between the finished malt and the corn it was made from are duly tabulated; but eminently satisfactory and useful as these analyses are, they do not furnish all the information needed by the distiller, brewer, farmer, and physician.

The industry is an important one. For very nearly two centuries it furnished a large and constant revenue to the State, in the form of a direct tax upon the product or finished manufacture, producing every year for more than half a century upward of 5½ millions sterling.

In 1879–80, the last year of the collection of the Malt Tax, the amount paid was 6¾ millions sterling, while during the seven preceding years it amounted to:

1879	£7,739,507
1878	7,721,548
1877	8,040,378
1876	7,654,671
1875	7,746,740
1874	7,753,617
1873	7,544,175
	£51,200,636

£51,200,636 ÷ 7 = £7,314,375—annual average.

The quantities of malt made during the last three years of collection of the malt duties were:

	Bushels used by brewers.	Bushels used by distillers.	Duty free for export.
1878–9	58,036,155	7,189,275	507,805
1877–8	58,137,196	7,466,610	536,384
1876–7	60,526,682	7,049,466	511,692

176,700,033 + 21,705,351 + 1,555,881

= 199,961,265 ÷ 3 = 66,653,421 bushels ÷ 8 = 8,331,677 quarters—mean average for the last three years in which correct quantities were tabulated.

These figures, however, do not include the large quantities made for, and used secretly in, illicit distillation. Since the repeal of the Malt Tax, the quantity of spirit so produced has doubtless increased, for, as pointed out by me in a paper entitled "Some Results of the Repeal of the Malt Tax," and read at the Swansea meeting of the British Association, 1880, the power to make malt entirely free from supervision of the Excise must tend to such a result. Herein we find a cause for the recent diminution of the Spirit Duty, which I suspect is greater than Excise officers admit. As 600 to 700 illicit stills are found and destroyed per annum, it is fair to assume the number undiscovered is considerable, and the quantity of spirit made to be large.

Although Great Britain makes the largest amount of malt of any separate state in the world, several other countries make very large quantities. In the absence of returns, it is not possible to make comparisons, but from the quantities of beer brewed I have calculated that the quantity of malt consumed by brewers in Europe and America is considerably over 170,000,000 bushels per annum.

	Bushels.
Great Britain consumes over (exclusive of private brewing).	50,000,000
Germany and Austria consume over	60,000,000
Belgium and France " "	20,000,000
Russia, Holland, Denmark, Sweden, Norway, Switzerland, Italy, and Greece consume over	13,000,000
America consumes over	27,000,000
	170,000,000

In addition to this there is a very large quantity used for making spirits, bread, cattle food, and many other purposes which cannot be ascertained with any approximation even to accuracy, but in Britain alone the distillers use upward of 7,000,000 bushels per year.

At a low computation the capital permanently invested in malting in Britain may be estimated as follows:

Value of buildings	£15,000,000
Value of appliances and tools	2,000,000
A total of	£17,000,000

As the raw material can be purchased once each season only, the value of the corn used in ordinary seasons about equals the value of the malthouse in which it is made, so we may assume the working capital involved in the business in Britain to be nearly another £15,000,000.

The number of men needed rightly to make eight million quarters of malt per year should not be less than 14,000.

The actual number of maltsters enumerated in the last census returns is 9,531.

The total number of malthouses and licenses shows very remarkable fluctuations. Thus, in 1785, when the maltster's license was first collected, there were in:

	England.	Scotland.	Ireland.
1785	12,314	1,567	*
1800	8,752	311	—

A falling off in fifteen years of 28 per cent. in England and 80 per cent. in Scotland.

With slight annual fluctuations, these figures stood nearly stationary for twenty-five years, until 1825, when there were:

	England.	Scotland.	Ireland.
1825	9,595	1,758	339
1826	10,468	3,943	395

These high numbers kept up for twelve years, when a steady decline set in until 1880, the last date of collection of licenses, when the numbers had dwindled down to—England, 707; Scotland, 150; Ireland, 49; a total of 906 for the United Kingdom.

This number will probably still further diminish, should brewing continue to become a closer monopoly; otherwise every brewer will eventually become a maltster also.

The days when nearly every parish or district had its small malthouse are passed, much to the benefit of the industry as a whole, and so long as the duty continued it was no loss to agriculture; but the concentration of the industry in comparatively few great centers will eventually occasion greater direct loss to the English farmer than it has already accomplished.

Two centuries ago, when the population of this country was only 5,000,000, the quantity of malt made was six bushels per head, or 30,000,000 bushels. One century later, when the population was nearly 10,000,000, only 28,000,000 bushels were made, or 2·8 bushels per head. In 1880, with a population of nearly 35,000,000, the malt made was but 65,000,000, or less than two bushels (1·85) per head. The calculations made frequently as to the diminution of beer drinking indicated by these figures are so far inaccurate, because it is usually forgotten that we now produce from the same quantity of malt twice as much beer as they did two centuries ago. At the time when malt liquor formed the staple and almost exclusive drink of the Teutonic races, the consumption of malt was very large. Beer was made stronger then than now, and also very inferior in every other respect. During the periods now compared, the consumption of tea, coffee, wines, spirits, and mineral waters has enormously increased.

Malt making will eventually gain largely by the repeal of the Malt Tax, but, as I pointed out, both before the repeal and after, at the meeting of the British Association at York, in 1881, farmers must lose largely. The arguments then adduced by me have never been refuted, and experience shows their correctness. English barley can never again attain to such prices as it might had the tax continued, and the benefits to farmers of securing malt for feeding purposes and brewing beer are so small that they do not—and never can—compensate for a reduction in the price of barley of one shilling per quarter. The tax created a monopoly in English barley, which practically kept the price at the fictitious level of at least four shillings per quarter above its intrinsic value. Farmers would not believe it, but it is proved by stern, incontrovertible fact. It is also not a little curious how suddenly the value of malt as food for cattle has depreciated. A little malt, as a condiment, is in many cases useful, but for general feeding purposes it is wasteful, unnecessary, and even, at times, harmful. Healthy animals, that have their teeth, do not require diastatic action to assist them to assimilate their food, and malt, however made, consumes labor. Certain soluble constituents of barley are also inevitably lost. The quantities of malt made duty free for feeding purposes were sufficient proof of this years ago, apart from the able experiments of Sir John Lawes. The power to make malt for feeding was granted in 1864, and we find that in

1865	60,247	bushels were made
1866	29,094	" "
1867	5,170	" "
1868	713	" "
1869	316	" "

Since 1870, none has been made, and the sudden falling away sufficiently explains the true feeding value of malt in quantity.

There are many kinds of malt produced, and several methods of manufacture in general use. Barley is most commonly malted, but wheat, rye, rice, and maize are at times, and in some countries, very largely employed. The malts generally recognized in commerce are known as white, amber, crystal, blown, brown or porter, black or patent, and gelatinized malt. In addition to these somewhat ambiguous but still fairly general terms, there are numerous local or other less known designations. Malt is used in the production of very many and varied types of alcoholic beverages, including whisky and other spirits, stout, porter, ale, beer, and other so-called malt-liquors, together with vinegar. It is also used for horse, cattle, and sheep feeding, and recently as human food in numerous extracts, bread, etc. It is further of use medicinally.

These facts sufficiently demonstrate the great extent and importance of malt making, and render self-evident the statement, that in the limits of a paper intended for discussion by this Society, it is not possible to deal fully with any branch, nor to do more than allude to several of the less important.

Confining ourselves chiefly to our own country, and to the more important phases of the subject, we may consider it under the following heads:

I.—The materials used in malting.
II.—The processes of manufacture.
III.—The crude and finished products.

* A paper lately read before the Society of Arts, London.

* No account kept of license charged in Ireland till 1818.

I.—THE MATERIALS USED.

The contention has recently been raised in papers of high standing, that malt can be only made from barley and solely by the process of germination. These contentions are obviously absurd. For many ages malt has been made in this country from wheat and oats, while the preparation of *chica* in Peru, *bousa* in Nubia, and *koji* in Japan, furnish illustrations of kinds of malting, independent of germination, which should not be overlooked in discussing this subject. Another mode of preparation of malt, altogether dissimilar from the common process of partial growth, is furnished in the gelatinization of corn.

Still the broad fact remains, that barley is much more extensively used for malting than any other fruit or seed, and this doubtless arises from the nature of the skin and its component parts. Barley husk furnishes better protection to the developing acrospire than the skin of any other fruit. Also, as the main end of malt is to produce special alcoholic beverages by ordinary methods of fermentation, or, to a minor degree, by distillation, it is found in practice that from the particular proportions of nitrogenous and starchy matter naturally found in barley, it is, in the first instance, better able to furnish the several sugars in the best proportion for conversion; secondly, the right food or pabulum to the yeast cells employed in splitting up the sugars of wort into alcohol; and, thirdly, to combine therewith the best flavoring, coloring, and other characteristics to the numerous products of the brewer, distiller, and various other traders and manufacturers.

Nearly one hundred varieties of barley are malted, and as certain characteristics are approved, or others condemned, by maltsters, the improved cultivation of barley has been much fostered by the industry of malting. Now that malt can be made entirely upon its merits as malt, totally independent of any fiscal or legal restrictions and bounties, the chief characteristics of good barley are curiously altered, and such alteration must greatly influence eventually the cultivation of barley in Britain.

It is now found that the characteristics of good malting barley are best classed in two groups, of four essentials and six non-essentials. Of these, placing them in order of merit, the four essentials are:

Vitality.
Condition.
Maturity.
Odor.

The six non-essentials are:

Size.
Weight.
Uniformity.
Color.
Appearance of skin.
Age.

The practical acceptance of this classification of the characteristics of barley most suited to produce beer in the best manner, virtually means a still further reduction of value of all barley grown in Britain. Size and weight have lost all the fictitious value conferred upon them by the Malt Tax.

The other materials malted are wheat, oats, rice, rye, maize, peas, and beans. Of these, wheat and oats alone are malted commercially, by growth in this country, and rice by gelatinization in Britain, or by mycelium growth in Japan.

Next to the corn used, the most important material to a maltster is water. Commonly it is supposed that any water will do for malting, but this is a sad and wasteful error. Hard and moderately saline water is almost always better, under any circumstances, than that which is soft and extractive. Another material, much overlooked in practical working, is the coal or coke consumed in drying. The hardest and best anthracite coal, or oven coke, should be alone used. It is not unusual to find common gas coke, wood, and other unsuitable fuel burned. The practice of making blown or brown malt by use of fagot or billet wood is wasteful and delusive, for it is an expensive way of securing color and flavor which can be better attained at much less cost.

Apart from a very small quantity of bisulphite of lime, or other similar antiseptic, to prevent mould or developments of other low organisms in the damp green malt, no other materials are commonly used by maltsters than those enumerated.

II.—THE PROCESSES OF MANUFACTURE.

The modes of making malt are few and simple. What is now commonly practiced in Britain is almost unaltered from that of our forefathers; indeed, maltings are working at this hour which employ no other tools, and do not make any better malt, than described by William of Malmesbury as made by the monks of many Midland monasteries in the time of Henry II.

Malt, to be properly made has to be steeped or saturated with water, grown, and dried in houses and utensils specially constructed for the purpose. Such houses are very rarely built of a size smaller than what is technically known as a fifteen-quarters steep, *i. e.*, every three and a half or four days they wet or steep 15 qrs. of grain, which gives a capacity of 120 qrs. of malt made per month. As houses of this character usually work for seven or eight months annually, their total capacity is considerably under 1,000 qrs. per annum. In many cases houses of this size are worked entirely by one man, who, during the four summer months, commonly follows some other craft, such as thatching or bricklaying. It is rather hard work for one man to attend to 15 qrs. in a small malting, but in larger houses it is customery to expect each man to work from 14 to 18 qrs. When malting commences in October, the maltster has to receive the barley, screen, sort, and pass it into the cistern steep, then couch and floor it, raise to the kiln and dry it, tread, screen, store, and again screen it, and measure or weigh into sacks for use. All this, involving constant care, skill, and attention, is performed for the wage of from 14s. to 21s. per week, or from £30 to £40 per annum. On an average, the value of the malt made would be about £2,000. The difference in the value of such malt, if well and intelligently made or carelessly attended to and spoiled, would be from £200 to £500, or more.

A malthouse has to be of strong, solid construction, and consists of two or more floors and a kiln. The shape and size are always ruled by the position of the house and the nature of the site; but they should follow the relative proportions that experience has taught to be the best for the purpose of making malt, that is to say, the length of the growing floor should always exceed the breadth by at least two to one. The growing floor is often below the ground line of the adjacent soil, to insure uniformity of temperature, and the cisterns are of varied forms and position. They should be so placed that control of the temperature of the steep liquor can be secured, as temperature in cistern and couch has great influence in starting growth. In but few malthouses in Britain, however, is any attention paid to this most important point. Corn should be screened into the cistern already filled with water, in order to allow the thin corn and refuse to float away. The water is best if run in from below and allowed to overflow at top, prior to a change of steep liquor, or at any time during the continuance of steeping, which operation lasts for from fifty to eighty hours. The cisterns should also be so made that the disagreeable labor of emptying by shovels is obviated. Grain will always run down to the couch frame if the cisterns are rightly designed and placed. Their capacity should also invariably be ample to steep the utmost quantity of corn the floor can possibly grow in the coldest weather.

The growing floors are made of many materials; probably tiles are most esteemed, but erroneously so. The idea has struck several maltsters of having a double growing floor, the upper one of some porous material perforated, so that ready circulation of air and discharge of the carbonic acid produced by growth may be secured. This plan is being worked in several places, and it raises a question of great interest and importance, but a porous floor for malt is a dangerous and undesirable thing. To grow malt at all in this way is doing in a perfunctory manner that which is worth doing well.

The size of the growing floor is the gauge of the capacity of the malthouse, and every measurement of all other parts should be calculated upon such size. A 15 qr. house, such as I have described, should ever have a superficial area of combined couch and floor room of 2,600 ft. if in the south of England, or 2,400 ft. if in the north of England or Scotland, unless any exceptional condition of altitude or position affect the mean annual temperature of the floor. It cannot be too often impressed upon all connected with malting in any way, that the two prime factors in making good malt are heat and air supply, and the manner in which they are communicated to, or absorbed from, the grain.

Throughout the whole of the early processes through which malt passes, it is important to secure a good supply of cool moist air to the corn, until the growth is stopped, which commonly occurs eight or ten days after steeping. In small and ordinary maltings, this air can only be given or controlled by regulation of windows, doors, etc., and the same means are employed to regulate temperature. In fact, these agencies, coupled with the use of the shovel in turning, and the particular construction or position of the house, are the only ones employed, in the vast majority of maltings of every size, to regulate or control the two chief conditions of malt making. A new invention of M. Saladin, of Nancy, is of great utility in regulating air supplies to large maltings and for many other purposes. It is called an "échangeur," and is an ingenious utilization of the well known rapidity of evaporation of any liquid when spread out in very thin layers over large surfaces and exposed to air currents. It consists of a series of cylinders of decreasing diameter placed one within another, consisting of finely perforated sheet iron. They are placed in a shallow trough of cold water sufficiently deep to immerse the smallest cylinder. When rotated at slow speed, all surfaces are kept wet, and a volume of air is either drawn or driven through. This in its passage first comes into contact with the cylinders, and if hot and dry becomes rapidly moist and cold, for the constant evaporation has a powerful refrigerating influence. By increasing the area of evaporation surface, and causing the water or glycerine to circulate in the trough, any column of air can be wetted to the saturation limit corresponding to its temperature, and reduced to the actual temperature of the water used. This apparatus accordingly gives the maltster complete control of the humidity and heat, as well as volume, of the air driven through germinating grain.

Growing barley is kept moving upon floors by partial or complete turning every few hours; it is also usual to sprinkle it with water, should it be required, during this time. The great art of a maltster is manifested in cultivating the radicles and acrospire in the best manner during this stage of the process. The corn, when sufficiently grown, is taken to the kiln, or drying-house, a building in which the conditions of air and heat are exactly opposite to those already described. Heated dry air is made to dissipate and remove as much of the moisture as can practicably be abstracted from malt, to utterly stop the growth, and, at the same time, to impart characteristic flavors, and influences which affect the flavor and color of the beer, spirit, or other product of the malt. The kiln should always be a lofty and roomy structure of brick, with a high-pitched roof, surmounted with a cowl. The area of the drying-floor should never exceed one-fourth, or be less than one-sixth, of the growing-floors, nor should the combined air inlets and discharges ever bear a ratio to each other exceeding that of 4 to 5. Inattention to, or ignorance of, this simple fact on the part of kiln builders has caused an enormous waste of fuel, and damaged immense quantities of malt. The furnaces of kilns vary greatly, and upon the form, the area of grate surface depends. The drying-floors should be two in number, placed a suitable distance apart. The lower one should have its distance from the fire regulated by the construction of the house and the character of the malt desired. In altering old kilns, I have had opportunities of trying all heights ranging from 5 ft. to 29 ft. In new kilns the right limits are from 12 ft. to 18 ft., somewhat ruled by utilization of the kiln for malt storage.

The first kiln in this country successfully worked with double floors was altered by me four years ago at Brighton, but very many are now at work in all parts. Instead of green or wet malt being raised to uncertain temperatures upon one floor, where it has frequently to be turned, it is put for from forty to sixty hours upon the top floor. It is then dropped upon the bottom floor, a further charge of green corn following at once upon the top. The benefit is mutual. The malt below is maintained at a uniform heat, for it is virtually plunged in an air bath; free radiation is prevented, for the top surface of the malt is necessarily nearly as warm as that next the wire, which as a consequence may be kept lower than would be necessary if free radiation from the surface were allowed. The top floor, by the intervention of the layer of malt between it and the fire, is prevented from coming into direct contact with heat of a dangerous and damaging degree, for excessive heat, when corn is still green, not only gives color, but causes other grave evils. The same heat which is used to dry one floor, and in an ordinary kiln passes at once into the air and is wasted, is the best form of heat to remove the moisture from the second layer of malt at a low temperature. It is of vital importance to retain this green malt at a low temperature, as long as any degree of moisture exceeding, say, 15 per cent. is retained by the corn, for there is very little doubt that the influences of heat and moisture at this stage of malting are among the most important of any the brewer can exert in brewing. By them the quality of beer is very greatly affected. The degree of heat upon kiln and the duration of particular temperatures rule the percentage of dextrine produced by the malt, the color of the resulting wort and beer, and, in a most marked way, its stability. A final distinct advantage of double floors is the abolition of turning the drying grain, which, in ordinary kilns, is disagreeable and wasteful work. Not only is labor saved, but the very serious injury is averted of placing dry malt above that which is damp and of allowing it to become repeatedly dry and wet by the absorption of the steam given off by the damper portion. The economic advantages of this form of kiln are manifestly considerable.

All maltings worked in the common manner, together with those worked upon the Stopes system, labor under the disadvantage of inability to control rightly the temperature and conditions of air supply, or germinating grain. A comparatively new form of malting is known as the pneumatic system, which may be freely described as the absolute control of the conditions of all air supplied to growing grain, and its consequent modifications of growth. This has been for several years known in Britain, and is largely adopted abroad. Owing to our singular insular prejudices, only four of these houses are yet at work in Great Britain, notwithstanding that the users are well pleased with them; and they possess numerous advantages, with only one disadvantage (if it may be called one in this mechanical age), viz., the consumption of greater power, and a consequent reduction in the number of workmen to one-third of that otherwise necessary. The area occupied by the buildings does not equal one-third of ordinary houses, while the actual growing floor-space is only one-seventh. The use of plant and premises is continuous, the process of malting being equally well conducted in the hottest weather. The great advantage of this is, that brewers secure entire uniformity in the age of malt, while, by the old system, the stocks of finished malt necessarily fluctuate largely. All growing corn is subjected to the same conditions of exposure, air, and temperature. The volume of air supplied to the germinating corn is entirely under control, as are also its heat and humidity, and it is further freed, inexpensively, from all impurities, disease-germs, etc. The infrequency of turning the germinating grain benefits the growth of the roots, and the development of the plumula, besides saving much labor. No grains are crushed or damaged by the feet of the workmen. The capital employed can be diminished by the reduced cost of installation, the reduced stocks of malt in hand, and saving of wages. The quality of the malt made is much improved. The percentage of acidity is reduced, the stability of the beer increased, and a greater percentage of extractive matter of the barley is obtainable by the brewer or other user of the malt. These advantages must eventually be recognized, and in the course of time the adoption of this system will be general, if not universal.

The only other method of malting in Britain (excepting such minor modifications of drying as produce the various colored malts) is the gelatinization process. This was invented, comparatively recently, by Messrs. Gillman and Spencer, since the abolition of the Malt Tax. The industry has already attained considerable dimensions, for many hundreds of tons of rice and other grains are gelatinized every week. Rice is incapable of being malted by any ordinary process, but when gelatinized, it forms a singularly fine and useful ingredient in the manufacture of beer. Some of its advantages are its entire freedom from the evils inevitably present in malt; for no matter how much care be given to the cleaning of barley or purification of air and water, mould-spores and germs of other low organisms are always left in malt. The conditions absolutely essential to the right growth of malt are also those most favorable to the reproduction of all such organisms. The free use of antiseptics does not entirely overcome the difficulties naturally arising from such a state of things, consequently grown malt must be always liable to this defect.

Gelatinization effectually avoids this difficulty, for rice or any other grain which undergoes the high temperature and pressure of gelatinization cannot have clinging to them a single vital spore or germ.

This process of manufacture resembles malting only in the fact that the grain to be gelatinized is steeped. In common malting, corn is steeped for fifty or eighty hours, but by this method six or less hours suffice. It is then steamed under heavy pressure for a short time in a closed vessel of cylindrical form, from which it passes to the kiln to be dried. These kilns are patented, and are both novel and effective. The furnace and ensuing walls are of brick. The floors, which are of woven wire, rotate slowly over a series of drums, so that the moist corn is constantly fed from the top hopper, and while slowly progressing, is robbed of its moisture, and exposed to as much heat as may be desired. It finally reaches the bottom, and is discharged into the bottom hopper, from whence it is conveyed to any desired position for cleaning, sorting, and grinding.

It will be noticed how very greatly this process differs from common malting, and how completely it depends upon mechanical aid.

The changes produced in rice by gelatinization are indicated by the following analyses:

	Raw rice.	Gelatinized rice.
Water	12·51	9·63
Starch	74·81	77·22
Dextrine and sugar	1·11	2·96
Soluble albuminoids	0·41	0·13
Insoluble "	8·78	8·62
Cellulose	0·76	0·33
Fat	0·78	0·43
Ash	0·84	0·70

The rupturing of starch granules by combined high temperature and pressure, and the essential empyreumatic flavor given by high kiln drying in direct contact with the products of combustion, are not capable of tabulation. They, however, constitute the chief value of the process; the points of superiority, in addition to those already enumerated, are its remarkable rapidity and certainty of action. Grain can be received, steeped, steamed, dried, and ground entirely ready for use in eight hours (common malt takes from ten to twenty-one days). Every kernel, when gelatinized, is subject to precisely the same conditions of moisture, heat, and exposure, enabling the brewer to know accurately the composition of his wort, an element of uniformity impossible of attainment in ordinary malt.

All grown malt has invariably a large excess of diastatic power. Gelatinized malt is deficient in this respect, but whenever used in conjunction with common malt, the excess of diastase present in the mash tun is invariably sufficient rightly to convert the starch of the gelatinized grain. The high pressure and heat adopted during the process of gelatinization effectually rupture the granules of starch, making the constituent molecules enter freely into contact wtih the diastatic wort, which rapidly effects the change of starch into the saccharine compounds essential in worts. The peptonizing influences of gelatinization aid materially the formation of a wort duly containing the soluble albuminoids in that nice equilibrium so essential to the healthful growth and reproduction of yeast. Upon this growth the success of the brewer's operation so largely depends. The old belief in the superlative importance of fermentation in brewing has been freely questioned for some time. It is attributing causes to effects. It is now beginning to be accepted as true that fermentations are controlled greatly in the malthouse and mash tun. The power to gelatinize such nitrogenous grains as rice or starchy material as maize or wheat adds immensely to the power of a brewer to control properly his fermentation. To the general public such control has the direct advantage of improving the quality of the beer produced. Rational cultivation of the yeast is invariably and absolutely an improvement in beer, perceptible to the consumer.

The power to use other materials than malt in brewing may not be a decided advantage to farmers, but they should not have clamored so loudly and long for the repeal of the Malt Tax. Good rice or maize is quite as well able to produce pure beer as sugar.

Rice is malted in Japan in a very curious manner, which has been fully described by Prof. Atkinson in the Memoirs of the Science Department of the University of Tokio, in "The Chemistry of Saki" (1881).

The importance of this industry is indicated by the fact that nearly 6,000,000 barrels of saki are produced annually in Japan from koji and rice. This saki produces nearly twice the alcoholic strength of English beer. Koji is simply rice diastased by the growth of mould upon the exterior of the rice kernel, the growth of mycelium having a very similar effect to the development of the acrospire in growing grain.

III.—THE CRUDE AND FINISHED PRODUCTS.

Although malt is in itself, in some senses, a finished product, it is at the same time simply raw material for further use in the arts and manufactures. Certain very small quantities are eaten as food, without further preparation, but the bulk of malt made becomes the raw material to brewers and distillers. This is simple and self-evident, yet it is most difficult to convince maltsters that it is so. Fortunately, empirical methods of producing malt have caused certain rules to be established and recognized, which make malt sufficiently good for use, but nevertheless it remains a standing disgrace to our vaunted intelligence as a nation that millions of bushels of valuable grain are annually passed through processes of delicate and critical character, exerting most subtle influences, by men who know absolutely nothing of what they are doing. In 1877, over 60,000 bushels of malt were so utterly spoiled in Britain that the officers of excise allowed it to escape payment of duty, and every year—before and since—large quantities of barley have been similarly spoiled in process of manufacture. Such a thing is discreditable in the highest degree; for, given a man who knows live barley when he sees it, and who has sufficient knowledge of the conditions necessary to make that barley grow, and the power and skill to control rightly those conditions, it is simply certain that good malt will be produced.

In addition to this, much malt is made year by year which, although not positively bad enough to be rejected as malt, is, nevertheless, poor rubbish compared with what it might or should be, and losses constantly occur which are altogether avoidable. Indeed, there is no other industry which stands so greatly in need of reform and of a due infusion of intelligence and knowledge as that of malt making.

The few direct products of a malster are: malt, combes, and dust, none of which are waste products.

Malt is either white, pale, amber, crystal, blown, or black. Of these, the first three—white, pale, and amber—are made in the manner I have outlined, and the sole differences between them are occasioned by the barley from which they are produced, very slight modifications of growth, and chiefly by the methods of drying. White malt is made from the palest barley, worked in the best manner, and dried with great care. It never reaches a temperature exceeding one hundred and eighty degrees Fahrenheit at any time, except in singularly good kilns, and is kept carefully below one hundred and twenty degrees so long as ten per cent. of moisture remains in it. Pale malt is almost identically treated, but may be a darker barley, and carried to a temperature of two hundred degrees or two hundred and thirty degrees. Amber or imperial malt is common barley very frequently mismanaged, or discolored from various reasons, chiefly by neglect during the drying process, or it is intentionally carried to a higher heat upon kiln.

This question of heat upon kiln is one of great importance, and affects all users of malt in every operation. Experience has long taught that according to the heat of the malt upon kiln the stability of the beer produced could be accurately regulated; indeed, Combrune wrote very clearly upon this subject one hundred and twenty-five years ago. More recent writers have further pointed out that still greater influence is exerted upon the vitality and constitution of yeast cells by differences of only a few degrees upon kilns. Yet in some of the largest and newest malthouses in Britain—even in Burton itself—we find differences of temperature in the malt greater than those needed to make white into pale, or pale into amber malt, if applied at an early stage of drying. Indeed, the differences in temperature that will convert pale malt into amber or imperial are actually less than are to be found, in the vast majority of kilns, in the temperature of that pale malt lying in contact with the tiles or wire, and the upper surface exposed to the air. There are probably few kilns in England (having only a single floor) in which this difference is less than fifty degrees. Pale malt next the tiles will be at two hundred degrees Fahrenheit, and upon the surface one hundred and fifty degrees, or less; and malt heated to two hundred and forty degrees would make amber or imperial malt, unless it was nearly dry.

Crystal malt varies still further, as it is green malt, not fully grown, taken straight from the floor, placed in a woven-wire cylinder, over a fire, and rotated. The curious sweetness of crystal malt to the palate may be readily accounted for by the mode of its drying. Sufficient moisture is present at high temperature to enable the soluble albuminoids to convert a portion of the starch into sugar, for, as the malt when first heated is saturated with water, the amount of steam generated is considerable.

It is a very common opinion that malt contains much sugar, because of its sweetness. This is simply a popular delusion, as malt rarely has more than one-half per cent. of sugar, and often none at all. If the tongue and palate be dried, and malt flour be placed thereon, very little sweetness is detected; but the moment the saliva comes into contact with the flour, the peculiar and well-known sweetness of malt is perceived, as the diastase can then act upon the molecules of starch, and conversion to sugar instantly commences.

The following analyses show the value of the changes induced by malting in the different classes of malt already mentioned:

COMPOSITION OF BARLEY AND MALT (OUDEMANS).

	Barley.	Pale Kiln-dried.	Sun-dried or Air-dried.	Amber.
Starch	67·0	58·6	58·1	47 6
Dextrin	5·6	6·6	8·0	10·2
Sugar	0·0	0·7	0·5	0·9
Albuminoids	12·1	10·4	13·6	10 5
Cellulose	9·6	10·8	14·4	11·5
Fat	2·6	2·4	2·2	2·6
Ash	3·1	2·7	3·2	2·7
Products of torrefaction	0·0	7·8	0·0	14·0

The following analyses of barley, and of malt, prepared from the same grain, were made in the course of last year by the late regretted Mr. G. W. Wigner and his colleague, Mr. R. H. Harland:

	British.		Smyrna.	
	Barley.	Malt.	Barley.	Malt.
Starch	68·04	65·22	63·54	57·08
Dextrin	1·71	5·43	2·00	5·30
Sugar	0·00	5·78	0·00	5·56
Albuminoids, soluble	2·27	4·03	5·07	5·77
Albuminoids, insoluble	4·03	3·32	4·03	3·68
Cellulose	3·96	6·00	6·04	7·62
Fat and oils	2·67	2·26	2·24	2·59
Ash	1·25	2·30	3·20	5·32
Extractive matter	3·39	0·00	2·00	0·00
Moisture	12·68	5·66	11·88	7·08
	100·00	100·00	100·00	100·00

Percentage of nitrogen in albuminoids:

Soluble	1·01	1·18	0·812	0·922
Insoluble			0·644	0·588

The most noticeable feature in these analyses is the slight amount of startch actually converted to sugar in malt, and the readjustment of the molecules composing the starch and soluble albuminoids, commonly called diastase, in such a form that the conversion of starch into sugar is readily effected by the addition of moisture. It is probable that the amount of sugar indicated is in excess of the true amount ever present in dry pale malt.

Blown, brown, flare, or porter malt has the still further difference that considerable heat is applied with suddenness before it is dry.

It is well known that any given temperature over one hundred degrees Fahrenheit will give much more color to moist malt than a much greater heat could give to the same malt if nearly dry. Blown malt, accordingly, while wet, is exposed to the flare of fast-burning oak fagots or billet wood, and gains much color, flavor, and increase of size in consequence. It is laborious and difficult work to dry this malt, as the kiln floors are usually close to the fires, and the heat is trying to any one unaccustomed to it. The public taste for porter and stout, or "black beers," is steadily increasing, but the consumption of this sort of malt is deservedly falling away.

Black, burned, or patent malt is pale or other malt dried in the ordinary way, and then placed in a cylinder over a fire, and kept constantly and regularly turning. The starch and saccharine constituents are speedily caramelized, and a splendid deep color is obtained, which is communicated to porter and stout. The chief difference in the appliances used in the manufacture of crystal and black malts is the construction of the furnaces and cylinders. These have to be made in such a manner that free inspection of the malt can take place during roasting. They must also admit of ready lateral movement, to facilitate filling and emptying; and appliances for proper cooling are of importance. This manufacture is a singularly clear illustration of the apparently inevitable tendency of restrictive legislation to create close monopolies, for, owing to the high duty on malt, it was imperatively necessary to guard strictly against the loss to the revenue of barley being roasted which had paid no duty. Accordingly, a malt roaster was hedged in by law as jealously as a distiller, with precisely the same result—the creation of a close monopoly.

Gelatinized malt resembles other malt in practical use so far as its place as a raw material in the brewery is concerned, with the chief exception of its diminished diastatic power, and its freedom from husk, which formerly occasioned a slight difficulty in use.

Wheat malt would doubtless be much more largely made and used, especially at the present price of wheat, were it not for the difficulty of growing it with the acrospire outside the husk. Further, its excess of gluten, and other nitrogenous constituents, give brewers much trouble in their existing state of knowledge.

Oats, when malted, also labor under the latter disadvantage to a very large extent, and, in comparison with wheat and barley, they are, ordinarily, dear. Otherwise they malt freely, and, if brewed properly, make delicious beer.

Combes are the rootlets of the barley. They remove from the kernel a large proportion of the ash and nitrogeneous matters, as they consist of thirty per cent. or more of nitrogen compounds, with six to eight per cent. of ash. They also contain a great diversity of acids and other substances. Lermer detected upward of twenty distinct compounds in the samples he examined. They form good food for cattle and sheep, far better than any common food, and are much cheaper. Few farmers seem to be aware of their true position in this respect.

Kiln dust is a very minor product of malting, but is of use to farmers as manure. It consists of the combes or rootlets which fall through the wire or perforated floors of kilns, mixed with the dust and ashes carried by the ascending column of air from the fires, and then deposited.

The uses of malt are becoming more numerous, as it is found to be of considerable value for a variety of purposes. Of its use by brewers, distillers, and vinegar-makers every one knows, and its value to these traders is great. Its value to the agriculturist is, however, problematical. For bread and biscuit making, for various extractive condiments and medicines, we are still, as regards malt, in the experimental stage, and much remains to be discovered.

Malt bread is very palatable. It possesses the advantage of remaining moist and soft when several days old. It makes delicious toast, and altogether is of considerable advantage to sufferers from weak digestion, as it is practically partly digested food. To toothless infants who are fed upon starchy food, malt is a great boon, as, until the teeth are formed, children assimilate starch with great difficulty if at all; but if the starch is converted by the diastase of the malt prior to feeding, the infant can derive nourishment and strength from it.

The subject of malt making is a large one, and very much more could be said concerning it. No industry more urgently needs to have shed upon it the searching light with which this Society has so conspicuously illumined numerous branches of human energy. When empiricism in malting is at an end, and men are guided by the rational teachings and deductions of science, we shall have a very great improvement in all processes—improvements which will permit of great economies in that true sense in which loss and waste are prevented, and every product is utilized to the fullest extent of its natural capacity.

The battle between ignorance, bigotry, and greed on the one side and knowledge, freedom, and true wealth on the other has always raged, and with varying success, but usually with the result that knowledge eventually conquers. It is greatly to be hoped that, now that malting can become a rational and even scientific pursuit, it will afford another bright example of the benefit of freedom in strivings after perfection whenever and wherever efforts are made toward progress, retrenchment, and reform.

THE GAIT OF NERVOUS PEOPLE.

MM. Giles de la Tourette and A. Loude, in order to determine the difference in the manner of walking characteristic of healthy people and that of those suffering from nervous diseases, have adopted the following method: A large sheet of wall-paper is laid on the floor, and a longitudinal line is marked in the middle. The feet of the person experimented on are marked with rouge. After the necessary calculations, the impressions are reduced in size and photographed. Before studying locomotion in its pathological aspect, the experimenters ascertained the character of progression in a normal state. In each case the length of the foot was taken, and the impression left by it. The width between the feet during the act of walking was also taken, the measurement of angle formed by the opening of the feet, and its relation to the axial line, traced on the paper. The following conclusions were drawn from the study of patients with bilateral and unilateral lesions, from the onset of the affection until the end: The pathological step is more regular than that of a subject in a normal condition, both in length and the lateral separation of the feet, also the angle formed by the opening out of the feet.—*British Medical Journal.*

RECENT OBSERVATIONS IN MICRO-BIOLOGY, AND THEIR BEARING ON THE EVOLUTION OF DISEASE AND THE SEWAGE QUESTION.*

By F. J. FARADAY, F.L.S.

NEARLY three years ago, in a letter which appeared in the *Manchester Guardian* of February 14, 1883, as a contribution to a controversy on the work of Pasteur and Koch, I concluded as follows: "Pasteur is attenuating deadly parasites; before long some of his followers will evolve specific parasites from harmless saprophytes, and in the work of artificially evolving some at least of the species, such gases as carbonic acid will render powerful assistance."

Replying to this letter, in the same journal, a London medical man spoke of the prediction as without foundation. I was the more surprised by such an expression of opinion from London, as the *Times*, commenting a few months previously on a paper on Koch's tubercle bacillus which I had read before the Biological Section of the British Association at Southampton, had been good enough to say that I had shown that empirical medicine had a scientific basis. In that paper I had argued that deprivation of free oxygen, or cultivation in gaseous mixtures from which the normal supply of free oxygen present in fresh air is absent, probably had an influence in converting otherwise harmless organisms into the parasitic bacilli of tuberculosis. I had submitted that the lungs of persons of hereditarily narrow-chested structure, or of weak breathing habit, or of persons spending much time in a vitiated atmosphere, engaged in dusty occupations, or suffering from bronchial catarrh, presented the requisite conditions of culture, assuming the presence of the germs of organisms which might otherwise discharge a useful function in the chemistry of life, possibly even in the chemical function of the lungs themselves. Dr. Angus Smith had also pointed out (*Rivers Pollution Report*, 1882) that the putrefying process, when carried on in open rivers, such as the Clyde, does not seem to produce any marked form of disease; whereas the gases escaping from covered sewers are apparently associated with specific zymotic maladies; and he had suggested that "we require to learn whether any of the germs of disease, or which germs, will live in an abundance of good air." Dr. Smith had hinted that possibly the relative harmlessness of putrefaction in open rivers was a consequence of the less concentration of the resultant gases, or the more thorough putrefaction, oxidation, and destruction of the organic substances. Looking at the question from the biological rather than from the chemical standpoint, it seemed to me that with all these ideas floating about, and especially after the discovery of Koch's tubercle bacillus, there was considerable foundation for the suggestion that possibly certain gases might have an influence in converting micro-saprophytes into micro-parasites, and it did not seem a long step from this primary thought to the idea that carbonic acid might be such a gas.

As the carbonic acid idea was, therefore, in the words of Touchstone, "all ill-favored thing, but mine own," I may be permitted now to direct attention to a footnote appended to M. Pasteur's paper on a method of preventing hydrophobia after infection, read before the Paris Académie des Sciences on the 26th ult. M. Pasteur describes his method of attenuating the virus present in the marrow of rabbits which have died of rabies, by suspending portions of the marrow a few centimeters in length in dry air, the degree of attenuation being directly proportionate to the time of exposure, the dimensions of the fragment, and the temperature, the rabid property of the marrow being ultimately extinguished. The lower the temperature, the more slow is the process of attenuation. By this process a graduated series of infective material, suitable for prophylatic inoculations, is obtained. M. Pasteur then says: "If the rabid marrow be kept from contact with the air, in carbonic acid gas, in a moist state, the virulence is maintained undiminished (at least for several months), provided that it is protected from foreign microbic alteration."

M. Pasteur has not yet discovered any microbe as peculiar to rabies, though the fact that a perfectly definite period is required for the development of the disease when the virus is introduced directly to the nerve centers, which appear to constitute its appropriate *nidus*, is suggestive of the existence or evolution of a specific microbe. It is also as yet a mystery as to how, in the case of an ordinary bite, the affection is conveyed to the nerve centers; whether, by transmission through the blood, the specific infection ultimately obtains a lodgment in the ganglia suitable for its incubation, or whether an influence is conveyed through the nerves which sets up corresponding changes in Béchamp's hypothetical microzymes in the nerve centers, thus evolving from healthy material morbid organisms whose action is identical with that of the disturbing causes.

In this latter supposition we seem to see something analogous to induced electricity, and I may add that, throughout the whole of the phenomena of zymotic disease, there is a suggestion of action with corresponding and intensifying reaction. Given a micro-organism producing a certain effect upon an environment, that effect, in the absence of disturbing influences, seems to react upon the organism itself and increase its ability to reproduce the specific effect. To make my meaning clearer, let us suppose microbia present in a confined sewer. Their action results in the production of certain gases, and the presence of those gases again intensifies the action of the microbia. Or, to put another supposition, certain microbia present, say, in the peripheral regions of the nervous system, produce a given effect through the nerves upon the nerve centers, and that effect redevelops, from the "organic molecules" of the nerve centers, organisms or ferments capable of acting precisely as the original microbia acted. Such suppositions appear to offer explanations of the varying virulence of zymotic diseases, and of the discoveries by Pasteur and his disciples relating to the attenuation or intensifying of microbia. They may also provide the key to the mystery of protective inoculations. For the mild vaccine calls into existence a certain resisting power which appears to be intensified by the consequences of its own action.

Leaving such speculations on one side, however, for the present, what I wish now to point out is that in Pasteur's latest experiments we appear to have another illustration of the hygienic value of fresh air, and a confirmation of the suggestion that carbonic acid is a gas capable of at least preserving zymotic disease. May we not, hypothetically, generalize the idea, and carry it a little further, by saying not only that fresh air favors saprophytic life, while foul gases favor parasitic life, but that foul gases evolve parasitic from saprophytic life? It is a remarkable fact that no genuine pathogenic microbia have ever been obtained from collections made from the atmosphere. Dr. Miquel has made a vast number of experiments in the cultivation of atmospheric germs, only to arrive at the conclusion that pathogenic microbia "appear to be banished from the air." I venture to submit, however, that this does not imply that infection may not be communicated through the atmosphere. Attention has been called to the fact that epidemics often appear to follow heavy rains, and it has been suggested that the pathogenic microbia may be present in overflows of stagnant water, or may be washed into pools of water temporarily formed, so that, when these dry up, the germs are blown with the sediment into the atmosphere and inhaled, or deposited in milk or other beverages. As such conditions imply, however, not only the presence of abundance of fresh air, but also sunlight (to the hygienic action of which latter I am about to refer), the supposition is rather against the results of the experiments under consideration. If, however, we assume the presence of pathogenic germs in the foul atmosphere of ill-ventilated sewers, then heavy rains, or any other condition which diminishes the air space in the sewers, will force out more or less dense volumes, or gusts, of sewer gas, and the germs be conveyed directly to their new medium of culture, whether in the bodies of men or animals breathing such gases, or in the beverage which they infect; and they will be protected during their passage from the attenuating influence of fresh air by the appropriate environment which transports them.

We come now to the influence of light and darkness on micro-organisms, concerning which the results of some very interesting experiments, carried on independently by M. Duclaux and M. Arloing, have lately been made known. I proceed to consider these with the more pleasure, as they afford me an opportunity of again referring to one of those suggestive and thoughtful utterances which abound in the writings of our late revered member, Dr. Angus Smith. Referring to the fact that fevers have not been traced to open rivers, or to putrefaction in the open air, though they have been traced to decomposition taking place under cover, as in sewers, Dr. Smith observes, in a paper published in 1880, "The question arises, Is this owing to the concentration, or to the difference of decomposition in darkness, or to the better supply of oxygen? The effect of sunlight in warm countries does not allow us to suppose that the daylight always produces in vapors an innocent state, although it has a great effect in that direction when there is little water." M. Duclaux evaporated cultures of microbia in tubes, and then preserved the dried spores, carefully protected from external contamination, some being sheltered from the sunlight, and others being exposed to it, for various periods. The temperature of the sheltered tubes was regulated in all cases so as to be approximate to the maximum heat obtained from the sun by the exposed tubes, so that, excepting the light rays, the conditions in all cases were equal. On suitable infusions for culture being subsequently added, M. Duclaux found that the sheltered spores developed much more readily and abundantly than the exposed spores; the sunlit tubes proved, in fact, more or less sterile, according to the time of exposure, those which were exposed for the longest time entirely failing to give any evidence of microbe life. The fermentive action of the specific microbe experimented with, *Tyrothrix scaber*, is analogous to that of pathogenic microbia, as it destroys albuminoid matter, though it is important to bear in mind that it is what M. Pasteur calls an aerobic species. The dried spores of this microbe, when protected from the direct light rays of the sun, resisted the action of free air and a tropical temperature for three years, and germinated at the end of that period. A month's exposure to the sunlight, however, diminished the germinating power of the spores, and after two months' exposure, 50 per cent. of the tubes proved sterile. Similar experiments were tried with pathogenic micrococci. Cultures in broth preserved their vitality for at least twelve months, if sheltered from the direct rays of the sun. Exposure for forty days to the feeble and intermittent rays of the spring killed them; a fortnight's exposure to the July sun killed them; and exposure for a less number of days attenuated them, and deprived them of all power over the animals most susceptible to their influence. M. Arloing experimented with the anthrax bacillus, and found that sunlight diminished the vegetative power of the mycelium. Two hours' exposure to a July sun was sufficient to make a freshly infected broth sterile. Exposure for less than two hours retarded the vegetative power. When the spores are in process of actual development, however, the sunlight does not stop the growth; the mycelium grows and produces spores, the filaments break up, and the spores are set free. The process is, however, slower, and in this respect is analogous to the development as it takes place when the organism is cultivated in infusions which are little favorable to its growth. Sunlight, in fact, produces results analogous to those of culture in an unfavorable environment. When the mycelium has already developed spores in a darkened stove, exposure to sunlight for thirty hours stops vegetation. The power of growth is gradually weakened by exposure to sunlight, before it disappears altogether. If a drop of a solarized culture is used as seed for a fresh infusion, the vigor of the second generation is diminished in direct proportion to the length of time during which the parent culture has been exposed to the solarizing influence; the process of development is more and more protracted. Again, the diminution of vigor continues through successive generations. A third generation, the two preceding parent cultures of which have been exposed to the solarizing influence, if itself exposed to sunlight, loses its vegetative power more rapidly than either of the two preceding generations; the attenuative effect is, in fact, accumulated. These phenomena are accompanied by an attenuation of virulence if the successive cultures are inoculated in animals, and eventually the organism actually becomes its own vaccine. In proportion to the duration of the solarizing influence and its continuance through successive generations, a larger and larger quantity of the virus is necessary in order to successfully inoculate guinea-pigs with the specific disease, and the progress of the disease in the animal becomes slower and slower, until at length the influence is protective against the consequences of inoculation with an unsolarized or virulent culture.

It has been pointed out by a French writer that these experiments again confirm the doctrine, enunciated by M. Paul Bert, that any influence which arrests the development of a virus converts it into a vaccine. In the paper on "Pasteur and the Germ Theory," which I read before the Society last year, I argued that the difference between a harmless saprophyte and a deadly parasite was a difference of vigor. If I may formulate the idea again, I would say that a saprophyte is an organism which is able to utilize for its own life the residual forces in matter in which the specific or co-ordinating vital force has been extinguished; while the parasite is an organism which, in consequence of a given process of culture, is enabled to overcome the still existing specific vital force of the living organism on which it preys, and to divert that force to its own development. In some mysterious way light and oxygen are favorable to the vigor of the higher organism, and inimical to the vigor of the lower organism. These conditions determine which of the two is to be the subordinate. I have been led to think that the life-history of microbia is analogous to the earliest stages of the life-history of the higher organisms in this respect, and I am arranging some experiments in order to test this idea, the results of which I hope to communicate to the Society in due time. The higher plants and animals begin their lives in darkness, and as they grow they attain to light and fresh air; and then, if I may so express it, the higher life is progressively involved.

It is well to point out distinctly that as yet, however much reason there may be for believing that pathogenic microbia are really evolved from originally harmless ferments which have a great utility in the economy of the universe, and whose subordinate action may even be absolutely necessary for the existence of higher forms of life, such evolution has not yet been experimentally proved. Conversely, however, we have meanwhile definite evidence that fresh air and sunlight attenuate the virulence of pathogenic microbia. Even this partial knowledge is of great practical importance. It cannot be overlooked that vitiated air and darkness generally go together, and that, on the other hand, fresh air and sunlight are usually co-existent. Both the first-named conditions are necessarily associated in the covered sewer. Whether the covered sewer does or does not actually evolve the disease is at present a matter of speculation; but that the peculiar conditions of the covered sewer nurture and strengthen the disease may be regarded as experimentally proved. Now, I find that in connection with the ship canal project it is proposed to construct a covered sewer to receive all the sewage of this city. Of the conditions to be provided in this culvert we have as yet only the vaguest intimations. I confess that I, for one, look forward with the greatest anxiety to the prospect of such a huge drain, in which so vast a mass of organic matter will be allowed to putrefy in darkness and in the midst of an environment of foul gases. It seems to me that this Society will only be true to the traditions of its early history, and discharge a duty to the city to which it pertains, by watching this culvert scheme closely, and asking what provision is to be made for continuing the hygienic influences at present exercised on the Irwell by free oxygen and sunlight (so far as we possess either one or the other in this district), or what precautions are to be taken to counteract the vicious consequences of the absence of both.

The philosopher sees the same principles throughout nature; he learns to recognize that simplicity and harmony are the essential features of the constitution of the universe. The principles of one science reappear in all the others; the study of any branch of natural philosophy results in generalizations which elucidate the phenomena of other branches. And if he turns from the physical side of nature to its moral side, the thinker finds the lessons of the one applicable to the other, and confirmed by its phenomena. The recognition of this truth does not seem to me to be beyond the scope of science. Microbia have a beneficent function; Pasteur's pupil, Duclaux, has shown us that the seeds of the higher plants will apparently not germinate if microbia are excluded from the soil; and Pasteur himself has suggested that probably no young animal would live if its food were absolutely deprived of organized ferments. The evidence tends to show us that if these same ferments are compelled to live in the environment provided by their individual action alone, they become the agents of deadly disease. If we turn to the other extreme of the biological chain, we find that, with his physical nature deprived of sunlight and fresh air, and his mental nature compelled to feed upon its own vagaries, in short, with his mind darkened and unaerated, man himself becomes morbid and mischievous.

* Read before the Manchester Literary and Philosophical Society.

NOISELESS COAL FIRES.

THE sick, and those who watch by their bedsides, know how terribly disturbing is the noise of "putting coals" on the fire, whether they be violently thrown on in the manner generally adopted by servants and nurses (skilled or otherwise), or placed more carefully with the tongs, as kind relatives or friends will *sometimes* "make up the fire" in their sympathy with a sufferer. Even under the most careful manipulation, loose pieces of coal are almost sure to fall, and a disturbing rattle is the result. This may appear to be a very small matter to look back upon, but at the time it is by no means unimportant, and in some cases very great distress and even injury may be produced by it. The *Lancet* suggests a very simple precaution, which will suffice to prevent the annoyance altogether. If a few paper bags be supplied to the servant who replenishes the coal box, and these are filled with pieces of coal, nothing can be easier than to lift one or more of these packages on to the fire noiselessly, and so settle them that, when the paper burns, the coals may not fall out of the grate. By this obvious method, a noiseless coal fire may be secured.

SHORING.

SHORING, an operation that is very frequently called into use, is not a subject that we find treated in current literature very often, so that we think the following from the *Building and Engineering Times*, of London, will be of interest.

Shoring forms a section of carpenters' work often thought simple enough to be put in practice by rule of thumb, but in reality demanding much consideration, if principles lying at the very base of some carpentry are not to be scouted. A shore is a post or strut applied to a building to prevent fall or collapse, and its efficiency naturally depends on conditions similar to those governing the stability of timber pillars. Experiments have clearly shown that pillars with rounded or imperfect bearings are not nearly so strong as when the ends are fixed, and very few shores can lay claims to abutments whose finish and fastening at all approach the requirements of the significant and exacting term "fixed." The fundamental rule insisting on all cross strain being counterbalanced or met by direct support is also generally ignored in ordinary raking shoring, which consists of struts laid slopingly against a wall with one end resting on the ground. Flying shoring is distinguished by the struts or shores extending between opposite walls without touching the ground, and needle shoring is that variety where the shores are upright and support timber beams or iron bars called needles, which are inserted in holes broken in the wall and made to bear tightly against their top by means of wedges placed under the props.

Writers on shoring mostly agree that carelessness, wastefulness, and ignorance are often exhibited in its execution. It appears fair to observe that economy, and the desire to shake or cut into a dangerous wall as little as possible, connive at the rude nature of common shoring, which, being knocked together without any clear notion as to how it will be strained, is likely to be placed where it is least effective. Again, builders and workmen are prone to listlessly undertake jobs the uselessness of which is too palpable to men who look upon the plumb rule as conducive to effect rather than strength. On the other hand, it is satisfactory to find that a careful carpenter, alive to the doctrine that theory assists practice by avoiding redundance and waste, uses just as many shores as are requisite for the purpose, and generally succeeds in well fixing the work both absolutely and relatively to the disrupting thrust, though, as presently shown, raking shores, as customarily built up, are never deserving of much confidence.

It is no part of the present purpose to inquire why shoring thought imperative in one locality is not ordered in another, or why carpenters differ as to the details of its construction and application, but it may not be fruitless to glance at a fairly good type of a modern raking shore and note where its make seems at variance with the essential characteristics of strong framing. Taking the case of the ordinary compound one erected against a high wall, and consisting of top raker, middle raker, and bottom shore, an abutment for the heads of these timbers is obtained by fitting a deal, termed a side plank, wall piece, or walling piece, vertically to the brick work, and fixing it by means of short pieces of wood about one foot long and four and one-half inches square, called pins, studs, needles, or joggles. These are passed through mortises in the plank into holes made in the wall by removing headers or half bricks, and penetrate the wall and project outward beyond the plank about five inches or so, cleats being spiked to the latter immediately above the studs with the intention probably of stiffening them. Their presence, however, cannot sensibly lessen the cross strain tending to snap the studs where their upper edges bear against the brickwork. The foot of the bottom shore, pitched perhaps at an angle of 60 degrees, is planted on a sole piece or footing block firmly bedded on an unyielding foundation, often a peculiarly difficult condition to attain, its surface sloping away from the back of the shore at an angle somewhat greater than a right angle. The heads of the shores are cut with beveled shoulders, to fit snugly under the studs close against the walling piece, and are sometimes notched out so as to leave little erect horns to grip the stud and prevent sliding should great strain urge the shore to move laterally. With a scantling 12 inches by 6 inches, which is sufficient for a lofty wall, the thickness of the horns would only be ¾ of an inch, and moderate pressure intensified by leverage would soon tear them off. The bottom shore is often got home by gently coaxing its heel along the footing block with a crowbar, and making fast with a dog iron, but wedges must be used in getting the middle raker to its bearing, otherwise the difference of pitch would preclude the feet of both shores, whether beveled or not, from being fairly planted on the block. The outer shore, or top raker, frequently rides on the back of that below, and is hence surnamed the rider. Its foot abuts on wedges laid between it and a straining piece, reclining also on the back of the same shore, reaching some way up it, and resting likewise on the sole piece. The lower portions of the inclined timbers are strapped round with hoop-iron, and sometimes pairs of boards extending to the wall piece are spiked at intervals on opposite sides of the shores, or struts are introduced underneath perpendicularly to them, with a tantamount object.

Since the square is the strongest form of section for a timber strut, and the depth of shores, even in critical or important cases, is usually double their width, it would seem that the compound structure, as thus described, is no credit to the carpenter's art. The scantlings are erroneous, the strains do not pass down the axes of the shores, and cross strain and deflection, if met at all, are countervailed by contrivances altogether unworthy of the name of bracing. The joints, moreover, being frequently loose, the sole piece infirm, and the whole shoring exposed to weakening by wet, very little reliance ought to be placed in such unskillful support. When deflection occurs in a strut, its full strength has been reduced about one-fourth, and unless its ends are immovable, two-thirds more of it may be assumed as lost. Placing the rider, therefore, on the back of one of the shores is wrong, for it produces deflection, and tampers with the seats of the bearing ends. The use of shoring applies to a well-bonded and compactly built wall in jeopardy of overturning or inclining, as well as to one run up with the jerry builder's stock brickwork that has prematurely bulged or bowed. Horizontal struts—that is to say, flying shores—afford the best safeguard in both cases, and it is clear that there would be no vertical pressure upon them. Neither should there be any vertical pressure artificially brought upon the heads of raking shores. They ought to be wedged up closely to their abutments, and that is all, the condition of the wall and quality of the mortar usually necessitating the top studs to be inserted some courses down, else the outward horizontal thrust might cause the shores to slide upward and lift them out of place, thus contributing to the very catastrophe they were intended to avert.

SCHABLIOVSKY is said to have treated twenty-three cases of intermittent fever with tincture of iodine, with perfect success in each instance. In three cases, quinine and arsenic had failed previously.

DESIGN FOR A VESTIBULE.—BY F. BROCHIER, MUNICH.

IMPROVING WATER POWERS.

DAMS are frequently built in localities where the banks, upon one or both sides of the stream, are not as high as the water must be raised for the purpose of obtaining sufficient head. Here they extend outward to the higher land; and, although the water is comparatively shallow, this is liable to be the most troublesome portion of the structure to build and keep in repair, particularly if it is made of wood. In such places a stone wall, with a bank of earth in front of it, when properly constructed and composed of suitable materials, forms the best and most economical dam. Some recommend using the earth without the stones for this purpose, claiming that they convey the frost into the bank, loosening it, and forming openings through which the water is liable to force its way; but it is better to use both wherever the stones can be obtained, as they form a barrier that generally prevents the earth from washing away enough to cause much damage, even if the water finds a passage through it.

Prepare the ground for this portion of a dam by removing the surface soil from the place to be occupied by it. This is necessary, because it contains grass, roots, and other substances which will decay, and present a favorite harbor for earth worms and other vermin to burrow in and make openings for the passage of water. Then build the wall to the height required, making it broad at the base and considerably battering on both sides. Place the largest and best stones upon the outside, and lay its inside with the smaller ones, packing them as closely as possible to prevent the earth from working into it. There is the same reason in rejecting the surface soil in selecting the material for the bank as in preparing the place for it. Gravel is the best material for this use—not the washed gravel that may be obtained from the beds of streams in many places, but that found upon gravelly ridges, which has enough fine material in its composition, so that it will settle and form a compact mass when thoroughly saturated with water. Make the bank wide enough for teams with the carts used to be driven along upon it. Where the water can be raised as the work progresses, and the material kept thoroughly saturated, the men and teams will trample it into a compact mass that will be as nearly impervious to water as possible if suitable gravel is used.

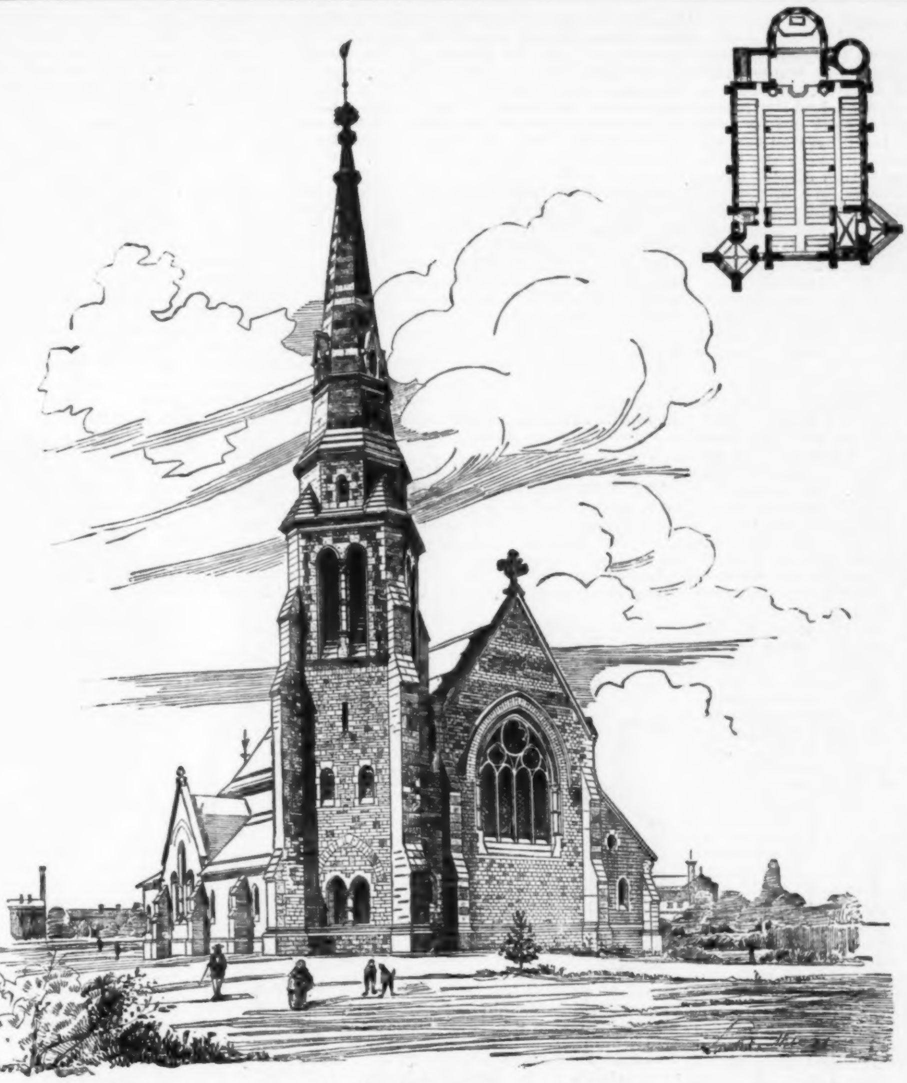
In places where this is not practicable, and the bank is made of dry earth—no matter how thoroughly it may be trampled down—considerable water will pass through when it is raised upon one side, but after being saturated it will generally settle, become compact, and form a tight dam. The proportion that a bank filled with dry earth will settle is stated to be about one-fifth of its depth, for which allowances must be made. After making the bank high enough, so that the water will not flow over it in time of freshets, put on a coating of the surface soil, and seed to grass. When this has grown, it forms protection from the frost, and its roots will prevent the earth from washing, even if some water should flow over it. A covering of stone is required upon the side next to the pond, to protect that from the action of the waves. No trees should be allowed to grow upon or very near such a bank, as the force exerted by the wind upon their tops is communicated through their trunks to the roots, which loosens the earth, and is liable to form openings, through which the water flows in a small stream that is sometimes the beginning of a serious washout.—*W. S. Fuller, in Millstone.*

MACHINERY AND ITS APPLICATION.

To a representative of a past epoch, the new applications of machinery and the new methods of manufacture are a revelation, but there are stranger things in store for their successors now coming upon the stage of action. There is yet a vast reserve of mechanical skill to draw upon, and the inventive genius of the age is just only beginning to be developed. The skillful machinist of to-day may seem a veritable ignoramus in the eyes of posterity, and the man of the next century will undoubtedly find much in the changes of a single generation to challenge his astonishment and defy his comprehension. The *Manufacturers' Gazette* thinks that we of the present do not realize that a boundless field of discovery is opening up to us, and that new explorations are being and will be made. Thus, at every step we shall find new and better, shorter and cheaper, methods, and that certain principles and devices are capable of being indefinitely extended. Though past achievements border upon the domain of the marvelous, they are but the alphabet to the possibilities and probabilities of the future.

CAST IRON WORK.

ARCHITECTS who are designing cast iron work ought to bear in mind a few practical rules. The cost of the patterns is often a considerable item in the expense, which should be taken into account. Thus, for example, says the *Building News*, a fluted or spiral column, ornamented by a capital and base, will entail a great deal of labor in making the pattern. The artist, wood carver, and pattern maker may be all required in the production. The price per ton will depend on the amount of labor and carving thus involved. The capital, if foliated, is often cast as a separate price, and fixed afterward, or the leaves and ornaments can be pinned on. Where hammered work cannot be introduced, ornaments made of papier maché or fibrous plaster will be found cheaper and more artistic than cast work. A useful approximation to the weight of a casting can be made by multiplying the weight of deal pattern by the number 17 for cast iron. In designing cast iron work attention should be paid to the following points: All changes of form should be gradual, avoid sharp corners and excrescences; leaves should not be undercut, and all angles should be slightly rounded off, especially if they are acute and are liable to damage. Abrupt differences in thickness, or in the bulk of the adjacent parts of a casting, should be avoided, or unequal contraction will produce fracture or weakness by causing a stress. In designing railings, gates, crestings, balconies, and other ornamental iron work, particular attention is required to these rules. We are repeatedly seeing cast iron railings mutilated, or the foliated parts, ornaments, and projections broken off, by inattention to the very obvious rule of keeping the parts plain and of not making the scrolls and ornaments too fine. In this respect there should be a marked difference of treatment between cast and wrought iron work.



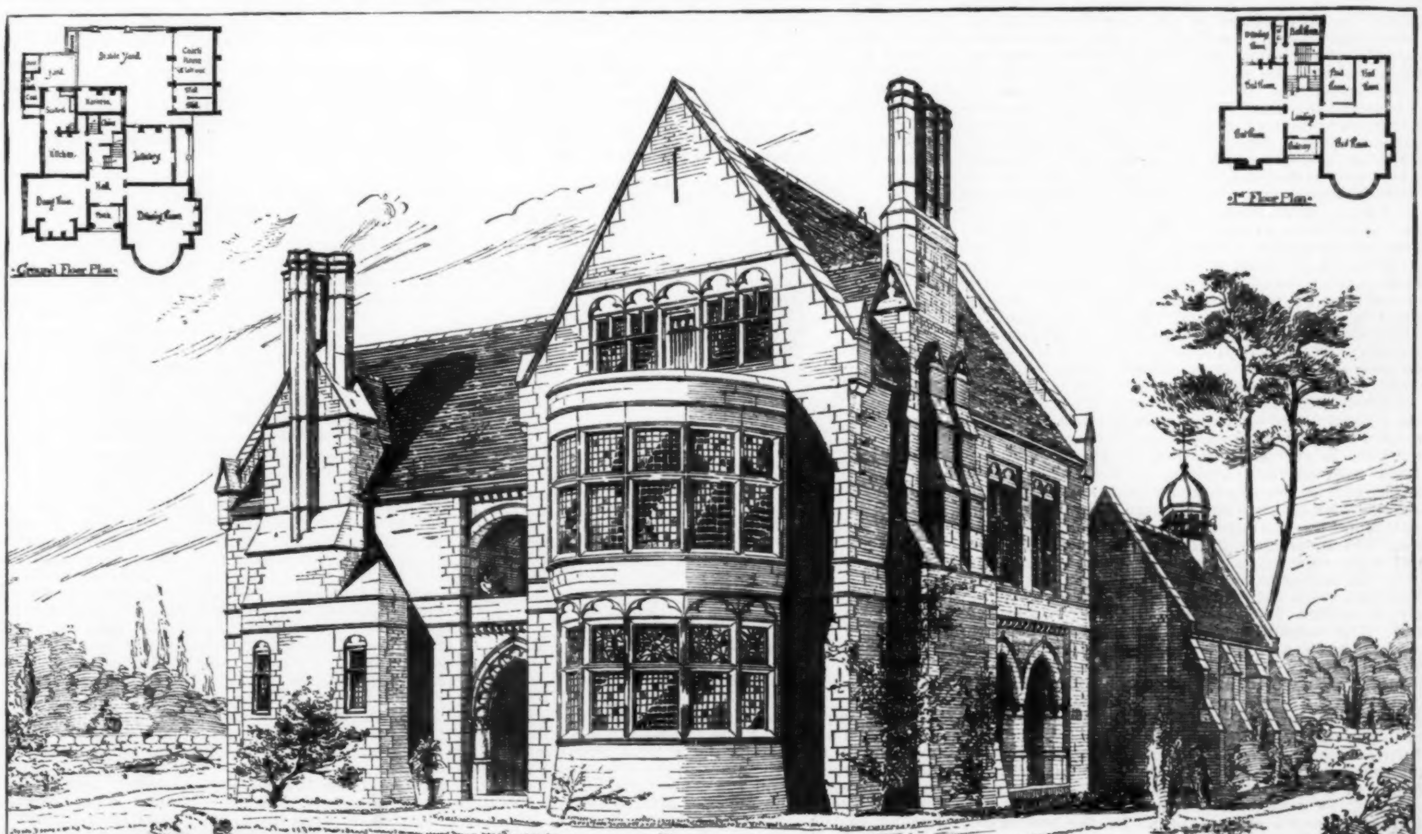
DESIGN FOR A CHURCH AT FRANKFORT.—A. v. KAUFFMANN, ARCHITECT.

PRIZE DESIGN FOR SUBURBAN HOUSE.

THIS design, from the Leicester School of Art, gained a silver medal in the national competition at South Kensington in 1884. It is faced with sand brick, with Sydnope stone dressings, and roofed with Swithland slates of diminishing sizes. The attics consist of four bedrooms and a large billiard room.—*Building News.*

TRANSLUCENT PICTURES.

The Paper and Printing Trades Journal mentions a new method of making "lithophanies," or translucent pictures, which comprises the following processes: Paper pulp, white or colored, in a liquid or semi-liquid state, is poured into a mould, usually of metal, the bottom of which is engraved to form or produce the desired design or picture. Enough pulp must be poured in to leave a thin film of paper over the highest lines of the engraved surface, when the pulp is dried, as will be hereinafter described. Those portions of the engraving which correspond to the dark shades of the picture are cut deeper than those which correspond to the lights, the depth varying with the depth of the shade. Upon the paper pulp in the mould is spread a piece of gauze, fine linen, or other similar material that will not adhere to the pulp, but will permit the passage of water, and on this is placed blotting paper in one or more layers, the whole being subjected to pressure in an ordinary press. The blotting paper thus absorbs the greater portion of the water from the pulp, and the latter is pressed into all the finer lines of the engraving. For the blotting paper any other absorbent material—as some kinds of felt—may be substituted. After removing the mould from the press, the blotting paper and the linen or gauze separating material are removed, and the mould containing the partially dried pulp is subjected to artificial heat, as in a stove or kiln, to dry out the remaining moisture. The dried paper pulp is now removed from the mould, and will be found to consist of a continuous imperforated paper leaf bearing the design or picture, which will be fully brought out when the sheet is held up between the eye and a strong light. The thinner portions of the sheet will represent the lights of the picture, and the thicker (and less translucent) portions will represent the shades. The picture or ornament thus produced is called a "lithophany," and may be employed for lamp or gas shades, for transparent pictures for windows, etc., or, indeed, for any ornamental purposes to which such a picture or design is adapted. In lieu of using artificial heat to dry the pulp in the mould, it may be dried by the natural evaporation of its moisture. The mould is usually engraved, but the design may be formed in any way—as by pressure from a hardened relief plate.



NATIONAL SILVER-MEDAL-DESIGN FOR A SUBURBAN HOUSE. E W GIMSON ARCHT

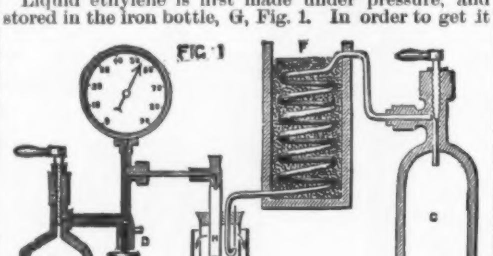
ACTION OF LIGHT.

At a recent meeting of the Berlin Physical Society, starting from the classical experiments of Bunsen and Roscoe respecting the action of light on a mixture of chlorine and hydrogen, Dr. Pringsheim had by recent experiments endeavored to obtain a closer insight into the mode of the action of light. Light, as was known, was absorbed to a definite amount by chlorine, while hydrogen had a coefficient of absorption almost equal to zero. When now light passed through a mixture of chlorine and hydrogen, a part of the light was, in the first place, absorbed by the chlorine, just as though this gas were the only element through which it passed, and in all probability this absorbed amount was transformed into heat. In addition to this effect, on the other hand, the chemical affinity of the gases got excited, and in order to this operation light was likewise absorbed. Whether in this process we had a direct action of light-rays transformed into heat or only a kind of releasing influence on the part of the rays was a point that had yet to be determined. The difficulty of this determination was enhanced by the fact of the induction which Bunsen and Roscoe had already ascertained, in accordance with which the chemical combination of the chlorine with the hydrogen did not take place at once, but only a longer or shorter time after the beginning of the irradiation. By taking the gas-layer of great thickness Dr. Pringsheim was enabled to augment the time of the induction to twenty minutes, and the combination of the two gases was effected only in the twenty-first minute of the irradiation. For his experiments Dr. Pringsheim made use of a gas-developing apparatus in which concentrated hydrochloric acid underwent electrolysis by means of iridium electrodes, and from which the gases passed through a tube into a globular irradiation space whence a capillary, divided into millimeters, led to a vessel filled with water, from which, again, a thread of water penetrated into the capillary, and so served as index of the gas-pressure obtaining in the apparatus. Any heating influence expanded the gases and pushed the index outward, while as often as hydrochloric acid was formed—the acid being at once absorbed by the water that was present in the insolation-globe—it caused an advance of the index, and the measure of this advance served as a criterion of the amount of acid formed. Experiments were next instituted in regard to the nature of the induction, and investigation was made as to whether it were identical with the chemical action of the light or were somewhat different from it. Sources of light of different intensity and different color were examined in respect of their chemical and their inductive action, and it always turned out that the rays of most intense chemical action produced likewise the greatest induction. In the measurements of the chemical action of light, which were then taken in hand, a petroleum lamp was used as a source of light, the warm rays of the petroleum lamp being eliminated by means of an intercalated layer of water. Dr. Pringsheim first observed a sudden movement of the index outward, which was at once followed by a speedy retirement to the initial position, and from this point the index was then observed proceeding slowly inward, in proportion as muriatic acid was formed and absorbed. Seeing the first movement of the index might be interpreted as an effect of heat, control experiments were instituted with momentary illumination, at first by dropping a dark screen with small slit before the flame, and then by means of electric sparks. Each time now that the light ray struck the chlorine hydrogen gas mixture, the index was seen pushing suddenly outward, and then as suddenly reverting to its former position, whence it then slowly retired inward. There could, therefore, be no question in this case of any heating, but there must, on the contrary, be some other cause in operation, to the determination of which other experiments should be devoted.—Dr. König spoke on color-blindness, and, in particular, on the important light it would throw on the theory of colors if, in addition to cases of red and green blindness, the existence of violet blindness could be demonstrated. Hitherto, violet-blind persons had been described only by Herren Donders and Holmgren. These gentlemen had examined abnormal eyes, which, in the spectrum between red and green, saw a circumscribed gray band, exactly at the spot where, in the case of the violet-blind, the two remaining curves of color-sensitiveness intersected each other. Last year, for the first time, Dr. König had an opportunity of examining an intelligent boy of from thirteen to fourteen years of age, who likewise testified to a quite distinct gray band in the spectrum between green and red, while he saw all other colors accurately. The belief that here was a case of a violet-blind person was, however, materially shattered when the spectral violet was presented quite pure and isolated before the boy. He then said he saw a color which he had never before seen in his life. The boy was, therefore, not incapable of perceiving violet rays. Later, Dr. König had occasion to examine an eye affected with central turbidity of the retina, an eye which—so far as the experiments that were capable of being executed only with great care allowed the determination of the matter—was, in point of fact, violet-blind. On investigating the neutral point, it was found with very great precision at the wave-length, 560·14. According to theory, the intersecting point of the red and green curve lay at 563·5 wave-length, very fairly, therefore, in agreement with the value thus found. The measurements of intensity between the wave-lengths 560 and 470 yielded values which likewise coincided exactly with those given theoretically for bichromatically violet-blind eyes. The now considerably more exact method for examining the color-blind and the significance of these ascertained facts in relation to the theory would be set forth by Dr. König on a future occasion. In the discussion which the first communication called forth, Prof. Landolt made the proposal of using a solution of lithium chloride in order to obtain, by way of electrolysis, a perfectly pure chlorine hydrogen gas mixture. In the case of electrolysis of hydrochloric acid there was a danger, he represented, of oxygen being united with the gas mixture. Prof. Von Helmholtz said that the influence of the rays of light on the chlorine and hydrogen molecules might be conceived by supposing that they acted in a manner similar to that of elastic balls executing oscillations in a high-standing flat vessel, whereby they were continually passing up and down. Did one ball receive on some occasion or other a stronger impulse than usual, then it leaped over the edge and fell to the ground; so that in respect of the totality of movements in the vessel, a part of the energy was lost. In the same way, when an atom of chlorine and hydrogen approached so close to each other that they united chemically, a part of the energy of the oscillations of light became lost. In reference to the second communication (that of Dr. König), Prof. Von Helmholtz set forth the difficulties of investigations of the kind in question, and laid special stress on a psychological difficulty. It was known that only the central part of the retina was trichromatic. With the part of the retina attaching itself peripherically, only two colors were seen, while the extreme region of the retina was monochromatic. Nevertheless, we always saw a white surface as white, whatever part of the retina was struck by these rays. It was plain that we had learned by experience to perceive objects that appeared white in the central field as white likewise when at the periphery they stimulated only two or but one kind of fibers. In all investigations into color blindness this psychological point was one which ought to be taken into quite material account.—*Nature.*

LIQUEFYING COMMON AIR.

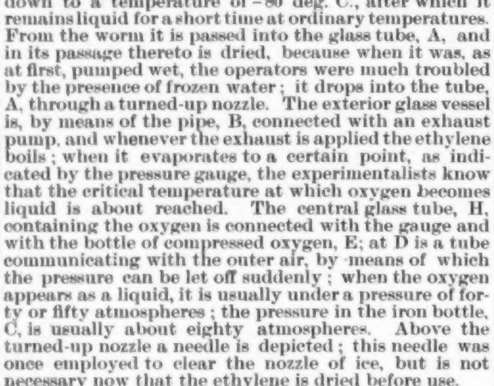
The chief experiment exhibited by Professor Dewar in a recent lecture before the Royal Institution was the liquefaction of common air, also oxygen gas, and the chief difficulty was to do this in such a way as to make the results visible to a large auditory.

Liquid ethylene is first made under pressure, and stored in the iron bottle, G, Fig. 1. In order to get it



liquid at ordinary pressures, it has to be cooled enormously, which is done by passing it through the copper worm, F; the worm is surrounded with solid carbonic acid and ether, by which means the ethylene is brought down to a temperature of -80 deg. C., after which it remains liquid for a short time at ordinary temperatures. From the worm it is passed into the glass tube, A, and in its passage thereto is dried, because when it was, as at first, pumped wet, the operators were much troubled by the presence of frozen water; it drops into the tube, A, through a turned-up nozzle. The exterior glass vessel is, by means of the pipe, B, connected with an exhaust pump, and whenever the exhaust is applied the ethylene boils; when it evaporates to a certain point, as indicated by the pressure gauge, the experimentalists know that the critical temperature at which oxygen becomes liquid is about reached. The central glass tube, H, containing the oxygen is connected with the gauge and with the bottle of compressed oxygen, E; at D is a tube communicating with the outer air, by means of which the pressure can be let off suddenly; when the oxygen appears as a liquid, it is usually under a pressure of forty or fifty atmospheres; the pressure in the iron bottle, C, is usually about eighty atmospheres. Above the turned-up nozzle a needle is depicted; this needle was once employed to clear the nozzle of ice, but is not necessary now that the ethylene is dried before use.

Fig. 2 is a representation of parts of the same appara-



tus, with variations. In this, C is the iron bottle with compressed oxygen, A the stopcock for regulating the pressure in the glass tube, F, and D is the pressure manometer; I is the fine copper tube which connects the gas reservoir and the glass tube, F. J is the air-pump gauge, H the place of attachment of the tube leading to the double oscillating Bianchi. The glass test tube, G, contains the liquid ethylene which is to be boiled *in vacuo*, and is placed, as already stated, in the middle of a larger tube. It has holes at E, in the upper part, so that the cool vapors in their course to the air-pump are forced to pass round the outside of the vessel, and help to guard it from external radiation; the lower part of the outer cylinder is covered with pieces of chloride of calcium, K. If a thermometer is used, and a continuous supply of ethylene maintained, the India-rubber cork through which the tube, F, passes has two additional aperture for the purpose of inserting the respective tubes. When the pump has reduced the pressure to 25 mm. the ethylene has a temperature of about -140 deg. C.; a pressure of between twenty and thirty atmospheres is then sufficient to produce liquid oxygen in the tube, F. The tube, F, is 5 mm. in diameter, and about 3 mm., thick in the walls, and when filled with fluid oxygen holds at least 1·5 cubic centim.

In his earlier experiments with this apparatus, Professor Dewar states, after speaking of the trouble of making liquid ethylene, that: "It was therefore with considerable satisfaction that I observed the production of liquid oxygen by the use of solid carbonic acid, or preferably liquid nitrous oxide. When these substances are employed and the pressure is reduced to about 25 mm., the temperature of -115 deg. C. may be taken as that of the carbonic acid, and -125 deg. C. as that of the nitrous oxide. As the critical point of oxygen, according to the Russian observers, is about -113 deg. C., both of these cooling agents may be said to lower the temperature sufficiently to produce liquid oxygen, provided a pressure of the gas above the critical pressure, which is fifty atmospheres, is at command. In any case, however, the temperature is near that of the critical point; and as it is difficult to maintain the pressure below about an inch of mercury, the temperature is apt to be rather above the respective temperatures of -115 deg. C. and -125 deg. C. In order to get liquefaction conveniently with either of these agents, it is necessary to work at a pressure of oxygen gas from 80 to 100 atmospheres, and to have the means of producing a sudden expansion when the compressed gas is cooled to the above-mentioned temperatures. This is brought about by the use of an additional stopcock, represented in the figure at B. During the expansion, the stopcock at A is closed and the pressure-manometer carefully observed. No doubt liquid nitrous oxide is the most convenient substance to use as a cooling agent; but as it is apt to get superheated during the reduction of pressure and boil over with explosive bursts of vapor, it is well to collect the fluid in a small flask of about 250 cubic centim. capacity, and to change it into the solid state by connecting the flask with the air pump, and then to use the substance in this form. The addition of alcohol or ether to the solid nitrous oxide makes the body more transparent, and thereby favors the observations. It is evident that this apparatus enables the observer to determine the density of the fluid gases condensed in the tube, F; since he has only to measure the volume of fluid in F, and to collect, by means of the stopcock, B, the whole volume of gas given by the fluid and condensed vapor, which gives an accurate determination of the total weight of substance distributed between fluid and vapor in the whole apparatus. The amount of substance which is required to produce the vapor is easily found by observing the vapor-pressure of the liquid gas before expanding it into gas for the volume measurement; and while keeping shut the stopcock, B, by opening A suddenly until this pressure is just reached, and then instantly shutting off the receiver. If this volume of gas is now measured by opening B as before, the difference between the two volumes thus collected will correspond to the real weight of substance in the liquid state. A rough experiment with oxygen near the critical point gave the density 0·65."

The results of the experiments were made visible to all in the theater of the Royal Institution, by projecting an image of the tubes, A, B, and H, Fig. 1, upon the screen, by means of the electric lantern and a large lens.

THE SHOOTING STARS OF NOVEMBER 27, 1885.

The night of November 27, 1885, was one of triumph for astronomers, as the rain of shooting stars that then occurred came to confirm their theory that these bodies are corpuscles that describe around the sun very elongated ellipses, which the earth may cross in her annual course around that luminary, and also to confirm the conjecture that shooting stars are the product of the disintegration of comets.

It would perhaps be bold to generalize absolutely, and say that all shooting stars are derived from comets, and that all comets end by breaking up; but it is no longer doubtful that the principal swarms of shooting stars follow in space the tracks of known comets, or that they are derived from old, disintegrated comets.

Many of our readers may have been witnesses of the rain of shooting stars of the 27th of November, 1872. During that night, from 6 o'clock till 12, stars fell from the heavens in a perfect shower, and the number of them was estimated at a hundred and sixty thousand. They all emanated from the same point of the heavens, near the beautiful star γ of Andromeda. The phenomenon was observed in all countries where the heavens were cloudless; but of all spectators, it was the astronomers who were most moved by it, and the following is the reason:

There was a comet that had long been lost, and all efforts made to find it had been fruitless. It had been wrecked in mid-celestial ocean. Before vanishing in space, and disappearing from the eyes of astronomers, this comet had split in two. It was discovered on the 27th of February, 1826, by Biela, and ten days later, and independently, by Gambart. Its period of revolution was six years and nine months, and, punctually to the time calculated, it made its appearance in 1832, and again in 1845, when the catastrophe happened. In fact, astronomers were quietly following it with their telescopes, and everything proceeded satisfactorily from Nov. 25, the day of its appearance, until Jan. 13, 1846, when it was observed to split and form two comets, a large and a small one, each having a head and tail, and the two making their way side by side in ethereal space. Then they slowly separated, and by Feb. 10 sixty thousand leagues distance could already be counted between them; and finally both passed out of sight. Calculation showed that they ought to return again in six and three-quarter years; and they did in fact, for they were next detected one fine evening in September, 1852, but they were much diminished, and were farther separated by a distance of five hundred thousand leagues. Since this they have never been seen again.

So Biela's comet, broken in two since 1846, was con-

sidered as lost. According to calculations, it ought to have turned up again in 1859, 1866, 1872, 1879, and 1885, but none of the telescopes aimed toward the heavens succeeded in discovering the least trace of it.

We are mistaken, and it is here that the event acquires all the novelty of its interest.

On the 27th of November, 1872, as we have just remarked, a rain of shooting stars of incomparable richness was observed pouring from the heavens. All these stars seemed to come from one radiant point situated in the constellation Andromeda. Now, the orbit described around the sun by Biela's comet is inclined upon the earth's orbit, and the latter consequently intersects it, at two points that are diametrically opposite, by a line that may be determined by calculation. The plane of the terrestrial orbit and that of the cometary orbit cross each other at an angle of 12°. The earth, whose velocity around the sun is 63,600 miles per hour, intersects this plane on the 27th of November, and exactly crosses the comet's orbit. So, as the theory put forth in

FIG. 1.—RADIANT POINT OF THE SHOOTING STARS OF NOV. 27, 1885.

1872 by Mr. Schiaparelli had led to the identification of the orbits of shooting stars with those of comets, and had shown that, in all probability, the shooting stars of Aug. 10 and Nov. 14 describe in space the same orbits as known comets, this rain of shooting stars of Nov. 27, 1872, was at once attributed to Biela's comet. This same evening, Klinkerfuss sent a dispatch to Madras, from the other side of the globe, reading: "Biela has touched the earth; look near Theta Centaur." The Madras astronomer directed his telescope toward the spot indicated, and found there a pale nebulosity of cometary aspect, but the bad weather that came on during the night and lasted several days prevented him from finding it again and identifying it. This same comet had already, in 1832, come near meeting the earth, and all Europe was frightened for the time being. If the earth happened to pass just through the head of a comet, with its velocity of 63,600 miles per hour, that of the comet being 90,000, we do not as yet know exactly what would occur. But fears were premature. On the 29th of October, 1832, the comet must have really traversed the terrestrial orbit, hard by the route taken by our planet around the sun, and 18,000 miles inside of the orbit. Provided the nucleus and tail had had considerable dimensions, the earth might have been involved in the nebulosity, and been bombarded, heated, or asphyxiated. But the distance between the two bodies could not have been less than twenty million leagues, and everything was saved.

Well, the event so much dreaded in 1832 occurred on the 27th of November, 1872, and was renewed on the 27th of November, 1885. But, fortunately for us, without doubt, the comet no longer existed in the state of a celestial body, since, from 1846, it had been dead and reduced to fragments that were strewed along its route, and the shock of which against our planet would be as harmless as that of a fly against a locomotive. This cosmic dust, on reaching the limits of our atmosphere, catches fire through friction. It results that no shooting star can touch the earth, as it is inevitably resolved into vapor before reaching the lower strata of our atmosphere. These corpuscles, in the first place, never come at us directly, but always obliquely, and slide, so to speak, over the external convexity of our atmosphere, and make their exit after following several tangents rather than sectors. Those that reach us most directly penetrate deeper, and remain with us; but they are dissipated in vapor, and their velocity has become *nil* before the resistance of the air allows them to reach the ground.

FIG. 3.—THE NOVEMBER, 1885, METEORS AS SEEN AT AMSTERDAM.

From what has been said, it will be seen that we make a distinction between shooting stars and aerolites. As far as appearance is concerned, we can doubtless pass from the smallest shooting star to the most luminous meteor, and from meteors to falls of aerolites; but we must not always stop at appearances. Shooting stars do not consist of bodies of all dimensions, from the size of a grain of sand to that of a block of stone or of a mountain. The best proof of this is that during the nights of November 27, 1872 and 1885, out of the hundreds of thousands of shooting stars that appeared in the zenith of the European continent, not a single fall of an aerolite was noted. Aerolites have a different origin. Nor, on the same occasion, was the passage or explosion of a meteor of the first rank seen or heard. The most striking phenomena were a few shooting stars of the brilliancy of Venus, and a few trains given off by the fusion of one or more stars in the heights of the atmosphere. On examining the region of the heavens occupied by the radiant point of November 27, Mr. Fabry, of the Paris Observatory, discovered on the 1st of December a small comet that had the aspect of a slight nebulosity. Its position was 0 h. 39 m. and 21° 2', that is to say, near ζ Andromeda. It was at first thought that this comet had something to do with the shooting stars, but a calculation of its orbit showed that there was nothing in this.

We now have three magnificent groups of shooting stars, which are undoubtedly associated with the orbits of comets, viz., that of November 27, due to Biela's comet, captured by the attraction of Jupiter; that of November 13-14, associated with the comet of 1866, captured by Uranus; and that of August 10-11, associated with comet III. of 1862, captured by a trans-Neptunian planet.—We condense the foregoing from *L'Astronomie*, and add another engraving showing the appearance of the meteors as seen at Amsterdam last November.

FIG. 2.—SHOOTING STARS OBSERVED AT TUNIS, NOV. 27, 1885.

MICROSCOPIC WRITING.

AT a recent meeting of the Manchester L. and P. Society, Microscopical and Natural History Section, Dr. Alcock, president of the Section, in the chair, Mr. Alfred Brothers, F.R.A.S., read the following note on "*Microscopic Writing*:"

The Lord's Prayer has always been a favorite subject for testing the powers of minute caligraphy. To write the two hundred and twenty seven letters within the space covered by the smallest coin is a feat of some difficulty, but that the same number of letters can be engraved on glass within a space so minute as to be almost invisible with the lowest power of the microscope, and the individual letters not defined clearly with an eighth object glass, may seem incredible. There is, however, in the possession of this Section a slide which contains the Lord's Prayer, written by W. Webb in 1863, within the space of the 405,000th part of an inch.

To find this minute speck requires the exercise of much patience, as it is not only necessary to have just the right kind of illumination, but the focus of the lens must be on the true surface of the glass on which the object is written. When once seen with a low power, it is not difficult to find with the same power; but with the half-inch and higher powers it is always a trial of patience, even when the position of the object has been carefully registered with a lower power, and you are sure that the object is central in the field. Perhaps with the achromatic condenser some of the difficulty may be removed.

It will be remembered that about twenty years ago the late Mr. Rideout presented to the Section a machine for producing minute writing. The instrument was lent by Mr. Rideout to Mr. Dancer, by whom it was recently sent to the Society. It seemed to me that as this instrument was purchased by Mr. Rideout at the great Exhibition in 1862, it might be the same with which the wonderful piece of writing, or perhaps it should be called engraving, referred to was executed. I, therefore, wrote to Mr. Dancer for information on this point. In reply he says: "The microscopic writing on glass of the Lord's Prayer referred to in your letter was at one time in my possession, and was, I believe, presented by me to the Microscopical Section. It was obtained from Mr. Webb, and he was the same person who exhibited the microscopic writing machine at the great Exhibition of 1862. Mr. Webb died about ten or fifteen years ago, but I cannot give the exact

date. I have a very strong impression that Mr. Rideout obtained the machine from him which was sent by me to the Society. If able to find Mr. Rideout's letter, it may confirm this." I have not received the letter, but, as what Mr. Dancer says confirms the impression I have of what passed at the time, there can be little doubt that the instrument is the one used to produce the writing referred to.

Under the microscopes I have arranged two other slides of minute writing, which have been lent to me by Mr. Armstrong. These are not *very* minute when compared with the one first referred to, and which I have placed under the third microscope, where you will see the object with an eighth object glass. Even with this great amplification the words can scarcely be read, but it can be seen that only greater power is required to make the whole legible. It happens that the covering glass is very thick, so that powers higher than the eighth cannot be used. It will be noticed that the name W. Webb, 1863, is distinctly legible, and very beautifully written.

Mr. Armstrong has given me some particulars of Webb's minute writing, from which it appears he was accustomed to write the Lord's Prayer in spaces of the 500th to the 10,000th of an inch, and, as we have seen, to the 405,000th, and the prices of these slides varied from 2s. 6d. to 70s.

HOW OLD DO MARES BREED?

It is understood that mares cease to breed somewhere between the ages of twenty-two and twenty-eight years. Persons of limited means are sometimes tempted to buy mares that are twenty or more years old, with the expectation that they may surely be depended on to produce several more colts—two or three at least—and that the colts will pay well for the investment and risk.

Mr. J. H. Wallace, of *Wallace's Monthly*, has been bestowing no inconsiderable amount of labor in preparing a table, showing the history of 1,000 brood mares, and at what ages they were still breeding. At 20 years old, 216 were still producing; at 21 years, 175; at 22 years, 141; at 23 years, 83; at 24 years, 49; at 25 years, 22; at 26 years, 8; at 27 years 2; at 29 years, 1; at 30 years old, all had ceased to produce. Mr. Wallace further writes:

In addition to the fact that this table may save many a man from disappointment and loss in buying old mares for breeding purposes, it will serve another and still more effective purpose in the detection and exposure of frauds in pedigrees. It is literally true that the pedigrees of American-bred race horses abound in the most glaring impossibilities. This is not only true of sires, but especially true of dams. As an illustration of this very common fact, we have now before us a pedigree that continues to be published year after year, extending to the sixteenth dam. The seventh dam in this long string is represented to be Virigo, by imp. Shark, and she was bred to Sumpter and produced the sixth dam. Now, if this is true, Virigo must have produced this Sumpter filly when she was thirty-four years old. Nobody can believe that for a moment, especially as there is no shadow of evidence or claim that the mare Virigo was then living or had produced a foal for twenty-four years before this Sumpter filly should have been produced.

It is not unusual to see paragraphs going the rounds of the agricultural and sporting press, to the effect that a certain mare lived to produce a strong, healthy foal at the age of thirty-two or thirty-five, as the case may be, and a great many people believe them. We are often importuned, by honest men too, to accept such fabulous claims as true, and it is just possible we may have done so, in some instances, before we began to study the experiences of the past, but we will not have anything more to do with this kind of nonsense. It should not be forgotten that out of a thousand mares, only six live and produce a foal at the age of twenty-six, and beyond that age, only two in a thousand have produced foals. To be on the safe side, therefore, we must look upon all mares claiming to have produced beyond the ages of twenty-four or twenty-five as abnormal, and as requiring the strictest scrutiny of the evidence by which the claim is supported, before it can be accepted as true.

WORKING OF SUGAR CANE, SORGHUM, OR CORN STALKS FOR THE MANUFACTURE OF SUGAR BY DIFFUSION.

Diffusion is, when applied to sugar making, the extraction of that substance by soaking in either hot or cold water. Every time you make tea or coffee, you make a diffusion; brewing of ale and beer is also diffusion.

In the *Sugar Cane*, a magazine published in England, and devoted to the sugar interest, but chiefly to that of cane sugar, there is an elaborate account of very extensive and important experiments in the diffusion of sugar cane, which has been highly successful, and has proved the important fact, not only that the expense of that process is very much less than the ordinary means of crushing the canes, but also that the yield of sugar is greatly increased. The best crushing that is done leaves fully thirty per cent. of juice in the refuse, and the ordinary crushing at least ten per cent. more waste; whereas, by the diffusion process, ninety per cent. of the sugar which the canes contain can be obtained. The power required for crushing the canes is very great, but the power necessary for cutting up the canes for diffusion is not more than one-fourth (¼) as great. The crushing rollers are extremely massive and expensive, and the machinery in some of its numerous parts is very liable to be broken and disabled; and as the sugar machinery is all made in Europe and imported into the sugar plantations, this fact alone speaks volumes for the diffusion process.

The writer has been used to diffusion on a large scale all his life, though not of the sugar cane; and in the experiments which were made on a Dutch estate in Java, he considers that the operators showed an amount of ignorance as to everyday details which was, to an American or Canadian, most marked and extraordinary; but the fact is that sugar-cane men have so much money and so little ingenuity and energy that they trust to their money to procure assistance from Europe, rather than to the ingenuity which is every day exercised on this side of the Atlantic. Indeed, it appears to the writer that the sugar-cane growers are greatly deficient in ingenuity and energy.

All this, however, would be of small consequence to the farmers of the Northern and Middle States, and to those of the Southern portions of Canada, did they not possess the power of producing the sorghum, which yields not only a very large amount of sugar, but also a substance of nearly equal value in the millet, or grain, which that plant produces, and the production of which does not appear to injure the production of sugar, although it may be doubted whether judicious tapping of the plant would not increase the production of the sugar; this, however, has not been proved.

As at present worked, the sorghum canes are stripped and crushed between iron rollers, and the juice obtained is then boiled down with the same ingredients as are used for cane sugar, and thus produces either crystallized sugar or sirup, according to the treatment pursued; but it is clear that the process is subject to the same defects as the ordinary processes of cane crushing, increased by the fact that the rollers used on sorghum crushing are greatly inferior to those used for the sugar cane, and also to the fact that few American farmers possess the capital necessary to procure good, heavy, powerful rollers and other iron machinery, and the further fact that the canes of sorghum must be taken from the place where they were grown to the mill to be crushed, and the refuse, which is excellent fuel, thus wasted.

Now, in the diffusion process these difficulties do not exist. An instrument like a chaff cutter, but more perfectly made, is used for reducing the canes of the sorghum to small pieces, or, rather, to a coarse powder, and all the vessels used, except the sugar kettles, may be wooden tubs, thus bringing the manufacture within the means of the sorghum grower, and thus enabling farmers to make, as well as grow, their own sugar.

We will now proceed to describe the process of diffusion as applicable to the sorghum, as the most interesting to our majority of readers, merely remarking that the stalks of the sweet corn may be treated in a similar manner, and that they have been found, by those who have tried them, to produce a large quantity of sirup inferior to the sorghum, and which so far is not known to have produced crystallized sugar.

Cut the stalks with the cutting machine into slices of one-eighth of an inch in length; this, it is believed, will divide all the cells, which contain the sweet sap, so as to bring it into contact with the diffusion water as much as possible. Let the water be as hot as possible; boiling will not hurt. Let the tub be deep, so that it contains from 4 to 6 feet of the mixture. Mash and mix it as much as possible, then cover close, and let it stand. (I say three hours; others do not say so long.)

The water must just cover the cut stuff, and if it is found to swell, more water must be added. The steeping tubs must be provided with a false bottom, filled with small holes, to form a strainer. The cock or tap is inserted between the true and false bottoms. When the mixture has stood a sufficient time, draw off the contents, which will be nearly as strong as the fall juice. When all has run off, begin to sprinkle boiling water on the surface, and continue that operation until the proceeds are found to weaken considerably. The more slowly the sprinkling is done, the stronger will be the solution. When the liquor at the tap runs weak, stop the tap, and fill up again above the surface with boiling water. Let it soak an hour, draw off, and sprinkle again, and you will have got all the strength out of the goods. This weak liquor should not go among the strong, but be reserved for the next day's mashing, being kept hot all the time. If it is kept at 160° Fahrenheit, it will not sour or alter.

The liquor which has come off first time will be nearly or quite 160° Fahrenheit, but that depends on how close the tub has been covered, and the heat kept in. Great care should be taken to keep in the heat, and prevent cooling.

When the goods in the tub are exhausted, they may be thrown out, and either used for cattle feeding or dried for fuel.

The tubs should stand at a sufficient slope for the solution to run out completely.

The liquor so obtained should at once be transferred to a vessel which can be brought to a boil, either with steam or fire. As soon as the liquor reaches 160° Fahrenheit, add a small quantity milk of lime to it, and let it remain for a time, stirring it well. Here you want test paper, which you can get from the druggist. The addition of lime should be sufficient to prevent blue test paper from turning red; and as the test paper remains blue, you have got sufficient lime; then bring the liquor gradually to a heat that is *nearly* boiling, but not bubbling.

As the liquor approaches the boiling point, a scum will rise, which must be carefully removed. The lime which has not been dissolved will sink to the bottom. When the liquor below the scum is quite clear, it will be a straw color, and perhaps greenish, but it will be clear. Then bring the whole to a boil, and keep it so for a short time. Then let it rest and clear. The clear must be carefully separated from the thick at the bottom, and the clear may at once go into the evaporating pans or vessels and be boiled into sugar; but as every one knows how to do this, I shall not describe it further.

When the liquor is first drawn off from the mash, it will be somewhat thick and turbid; this must be returned into the vessel, on the top of the mash, until it runs clear. The goods will form the best strainer you can have.

If the liquor when boiled with the lime is thick, it must be strained or filtered through factory cotton. It must be *clear* and *fine* before it goes into the evaporating vessel, as, if not so, your sugar will be thick and dirty.

It will thus be seen that any farmer who grows sorghum can by this operation, which is very simple, dispense with taking his canes to the mill, and save the expense of rolling them.

Fuller description of all the operations can be had at any time. EDWARD LEFROY CULL.

Port Perry, Ont., Feb. 15, 1886.

To Make Watch Hands Red.—Mix to a paste, over a lamp, one ounce of carmine, one ounce chloride of silver, and half ounce tinner's japan. Put some of the paste on the hands, and lay them face upward on a sheet of copper, holding it over a spirit lamp until the desired color appears on them.

CAN UNDERGROUND HEAT BE UTILIZED?

In an article by J. Starkie Gardiner in a recent number of the *Geological Magazine*, the above subject is presented with much novelty and interest. After describing the phenomena which prove that the earth's periphery is only a crust of solid matter floating on a molten mass, he asserts that this crust is more likely to be ten than fifty miles thick. He refers to the artesian well now being bored at Pesch, which has reached a depth of 951 meters, and states that the temperature of its water is now 161° Fah., and that the boring will be continued till a temperature of 178° is reached. The obvious deduction is that the heat of the earth will ultimately be utilized by man in the place of costly fuel and furnaces. "It needs no seer," he says, "to pierce the not distant future, when we shall be driven to every expedient to discover modes of obtaining heat without the combustion of fuel, and the perhaps far remote future when we shall bore shafts down to the liquid layer and conduct our smelting operations at the pit's mouth."

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